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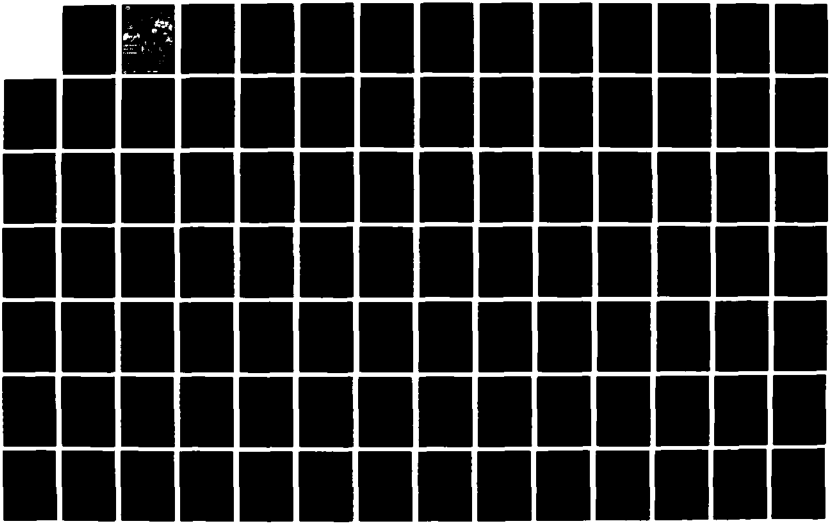

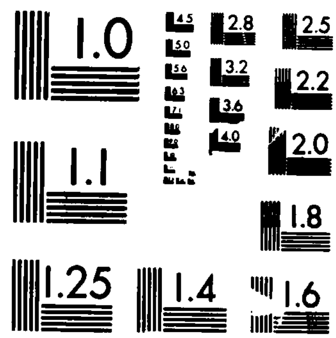

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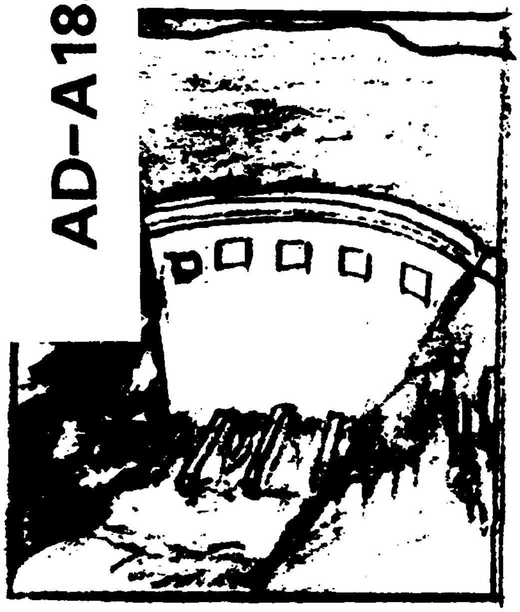

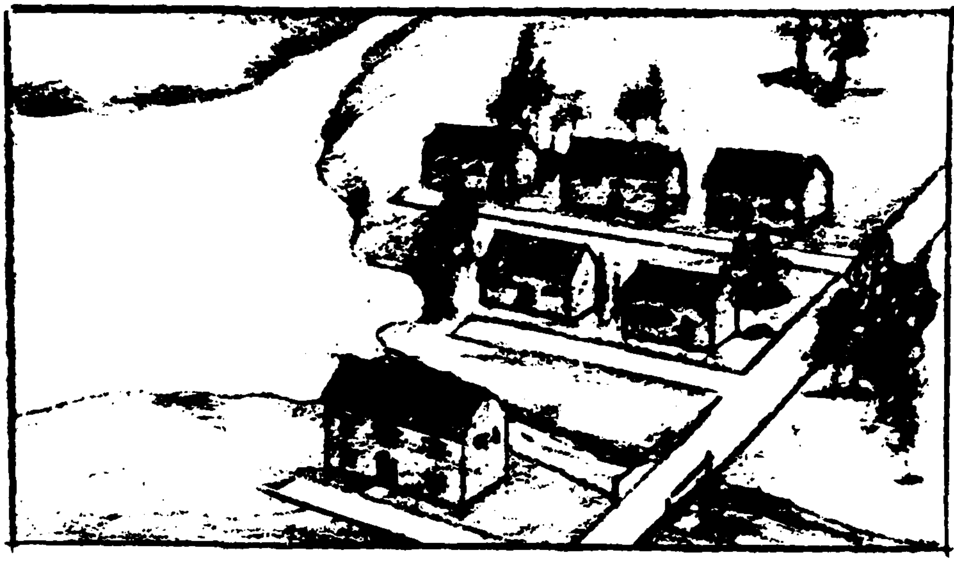

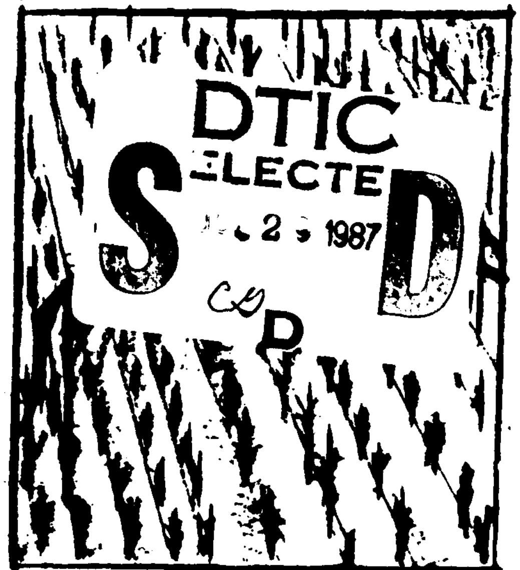

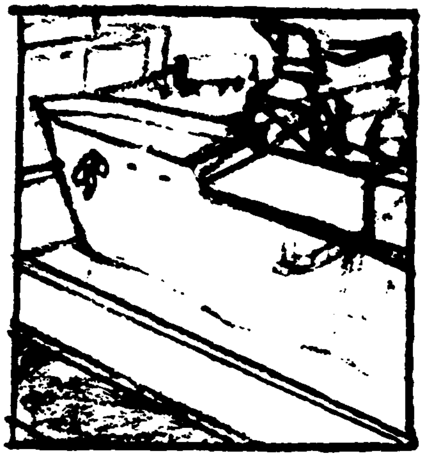

EMERGENCY WATER PLANNING

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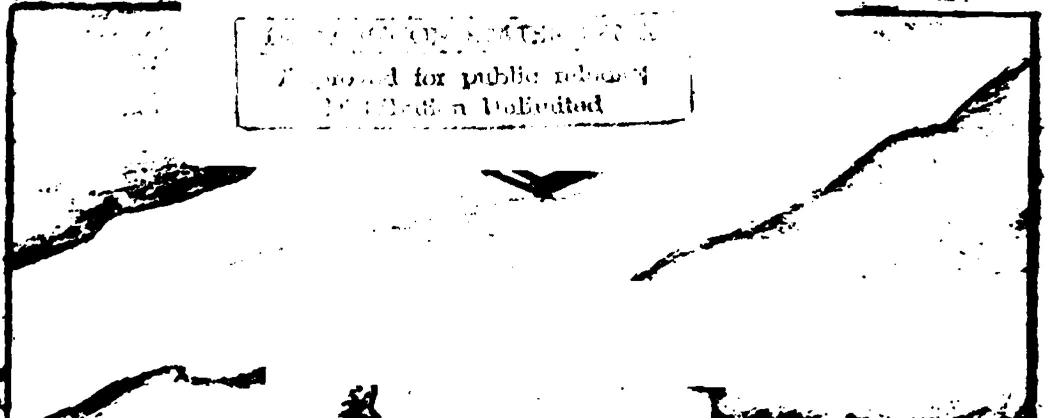

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This bibliography was compiled for the purpose of identifying and evaluating work performed to date in the area of planning for emergency water supplies in the event of major regional or National disasters. The bibliography evaluates the full spectrum of emergency water preparedness since Federal emergency water planning will rely heavily on a solid emergency planning base at the regional, state and local levels. All identifiable Federal and state laws and regulations pertaining to emergency water planning and assistance have been compiled and summarized. This work includes a critical assessment of present knowledge concerning the prediction of damages to water supply systems and the subsequent economic and social disruption caused by diasters. The annotated bibliography summarizes 133 studies of publications pertaining to emergency water planning. The bibliography also looks at the water supply impacts of the Great Alaska Earthquake of 1964, and, provides a list of supplies of equipment, materials, and services relevant to water system preparedness and recovery.

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EMERGENCY WATER PLANNING FOR NATURAL AND MAN-MADE EMERGENCIES: AN ANALYTICAL BIBLIOGRAPHY

by

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Benedykt Dziegielewski
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A Report Submitted to the

U.S. ARMY CORPS OF ENGINEERS
INSTITUTE FOR WATER RESOURCES
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FOREWORD

This bibliography was commissioned by the U.S. Army Corps of Engineers during development of the Emergency Water Planning (EWP) program.

Executive Order 11490 assigns emergency planning responsibilities for specific resources to various agencies. The Emergency Water Planning function was originally assigned to the Department of the Interior, then transferred to the Corps of Engineers in 1983. It is the Corps' responsibility under this executive order to plan for management of water and water support resources during national security emergencies to ensure that military and essential civilian needs are met. Before a plan could be formulated to do this, it was necessary to know what had previously been done in the emergency water planning arena to avoid duplication of previous work.

The scope of this bibliography is, therefore, broad to cover all aspects which might be related to the Corps' mission. The bibliography evaluates the full spectrum of emergency water preparedness since federal EWP will rely heavily on a solid emergency planning base at the regional, state, and local levels. It should not be inferred that all aspects of emergency water planning or preparedness covered in this bibliography will be covered by the Corps' emergency water plans.

Office of the Chief Engineer
U.S. Army Corps of Engineers

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The completion of this report was made possible through the generosity of many individuals who contributed time and/or materials to our research. Particular mention should be made of the state water resources and emergency management personnel nationwide who devoted their time and efforts to supply us with an extensive array of documentation. We are also grateful to the many authors who assisted us in the compilation of the analytical bibliography by generously providing us with relevant publications.

Special thanks go to the Anchorage Water and Wastewater Utility whose personnel readily supported the case study and provided us with substantial information. We wish to specifically acknowledge the following individuals:

Robert LeVar	Charles Bryant
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In every stage of development, this report benefited from the constructive criticism of personnel within the Chief of Engineers' Office under the supervision of James Crews and Barbara Brown. We are especially appreciative of the substantial contribution to the report made by Darrell Nolton, Contracting Officer of the U.S. Army Institute for Water Resources, whose participation greatly enhanced the progression of this study.

Finally, the production of this volume would not have been possible without the efforts of Brenda Pounder and Kim Bushe, whose skills were exceeded only by their patience. Appreciation is also extended to Theresa White for her careful editing throughout.

EMERGENCY WATER PLANNING FOR NATURAL AND MAN-MADE EMERGENCIES: ANALYTICAL BIBLIOGRAPHY

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I. ASSESSMENT OF EMERGENCY WATER PLANNING

I. ASSESSMENT OF EMERGENCY WATER PLANNING

INTRODUCTION

Water supply systems in the United States and elsewhere are subject to damages caused by a vast range of natural and man-made hazards. Many of the natural hazards such as earthquakes, floods, tornadoes, and hurricanes are typically of short duration, high intensity, and tend to be relatively localized events. Man-made hazards such as toxic contamination or nuclear explosions are capable of inflicting damages on vast areas of the country and developing into disasters that would threaten national security. Most research and formal emergency planning procedures are directed toward damage mitigation and rehabilitation needs associated with the acute local effects of natural hazards. Research and pragmatic mitigation efforts directed toward regional and national traumas have been neglected.

The purposes of this study were to assess the current status of unclassified emergency water planning at local, state, and federal levels of government and to identify the areas of inquiry where research can be expected to lead to major improvements in planning.

The remainder of this chapter provides an overview and conclusions of this study. The current status of emergency water planning and the state-of-the-art knowledge of emergency preparedness and mitigation are summarized. The major findings of the study are used to identify specific research needs in the emergency planning area and to formulate the desired characteristics of effective federal planning for national emergencies.

Chapter II describes the results of a compilation and review of federal and state laws and regulations pertaining to emergency water planning and assistance. Information used in the analysis was obtained from a variety of sources. Personal and mail contacts were made with a number of agencies including the Corps of Engineers, the Federal Emergency Management Agency, state water resources research institutes, state water resource agencies, and state emergency management agencies. Water resource entities were contacted in 53 states and possessions. The materials received from the above sources were used to assess the status of current federal and state emergency laws.

Chapter III contains a critical assessment of present knowledge concerning the prediction of damages to water supply systems and the subsequent economic and social disruption caused by disasters. Although the scope of this assessment included a full spectrum of both natural and man-made emergencies, the available information is limited to damages caused by such hazards as earthquakes and nuclear explosions. The effects of earthquakes are reviewed with the intent of summarizing the state of knowledge, while nuclear disaster serves to illustrate the difficulties and dangers inherent in conceptualizing the impacts of low-probability, high-intensity events.

Appendices to the report contain (1) an annotated bibliography comprised of summaries of 133 studies/publications pertaining to emergency water planning, (2) a case study of the Great Alaska Earthquake of 1964, illustrating the lessons learned from a disaster situation which may be applicable to other water emergencies, and (3) a list of suppliers of equipment, materials, and services relevant to water system preparedness and recovery.

CURRENT STATUS OF EMERGENCY WATER PLANNING

The status of emergency water planning in the nation has been assessed by reviewing the availability of formal emergency water plans and the statutes providing legal foundations for their implementation. The four phases of management activity--mitigation, preparedness, response, and recovery--were used to evaluate the comprehensiveness of existing federal and state laws and regulations.

Federal Laws and Regulations

Laws supporting the emergency planning process bring permanency, predictability, and enforcement powers to support emergency water plan implementation. Federal emergency water laws can be grouped under five types of water-related hazards to which they pertain: (1) general natural disaster laws; (2) national security orders and directives; (3) flood control acts; (4) water quality hazard legislation; and (5) drought hazard laws and assistance programs. Within these categories, there are 12 federal laws (including two executive orders) that authorize emergency water activities in the event of a disaster.

The amended Disaster Relief and Assistance Act of 1974 (PL 93-288) represents a general natural disaster law which provides national policy for coping with a variety of disasters. This law is all encompassing with respect to disaster type and delineates preparedness and response responsibilities of federal departments and agencies. Under the provisions of PL 93-288, the Federal Emergency Management Agency (FEMA) is authorized to direct and coordinate the activities of other federal agencies in providing disaster assistance. However, in case of water emergencies impacting on the entire nation, particularly when related to national security, the responsibility for the management, control, allocation, and use of all usable waters from all sources within the United States is transferred to the secretary of the army under the provisions of Executive Order 11490.

Emergency water laws categorized as flood control acts also provide for mitigation planning through the establishment of intergovernmental and interagency hazard mitigation teams to be activated immediately following a flood disaster. Water quality legislation covers the preparedness, response, and recovery phases and authorizes EPA to prepare guidelines for enforcement of water quality standards through court actions and for emergency response requirements in the event of hazardous oil spills or contamination of water supply. Finally, drought hazard laws authorize the Corps of Engineers to provide emergency well drilling and transportation of emergency water for human and livestock consumption.

In summary, there appears to be a noticeable lack of authorized or directed mitigation and prevention actions within all categories of federal hazard laws. In most instances, federal emergency provisions are formulated based on the assumption that the appropriate state and local emergency plans exist and are best suited to accomplish mitigation planning. Although it seems reasonable to accept such an assumption in light of the complexities of water supply jurisdictions, assurance can come only on the assessment of state and local (utility) planning.

State and Local Laws

A survey of state water resource centers and emergency management agencies conducted as part of this study produced documentation on laws, regulations, and emergency water plans from 45 states. Thirty-seven states and the District of Columbia have established authority to conduct emergency water planning. However, only two states (California and New York) have adopted planning measures that cover all four phases of emergency management (mitigation, preparedness, response, and recovery). Four states (Alaska, Connecticut, Nebraska, and Pennsylvania) align with three of the planning components while the remaining 31 states and the District of Columbia have planned for emergency measures in only one or two of the categories (see Table 1).

Cooperation between states is regulated by 34 interstate compacts that relate water management issues. Generally, these compacts do not address specific arrangements for cooperative efforts during water emergencies, although they often contain provisions for allocating water resources during droughts.

Many states require thorough emergency water plans at the regional or local level. However, emergency water plans prepared at the district, community, or utility levels do not seem to be widely available. Although no nationwide survey of local entities has been conducted during this study, the survey of the literature reveals that out of 133 publications selected for inclusion in this report, only 16 reported on existing water emergency plans, of which one was an interstate plan, one was a federal plan, four were statewide plans, and seven described utility-level plans (East Bay Metropolitan Utility

District; San Diego Water Authority; Corpus Christi Water Division; Philadelphia Suburban Water Commission; Richmond, Virginia, Water Bureau; Hartford Metropolitan District; and the Denver Water Department). This may be contrasted with the large number of articles and reports which contain general emergency planning guidelines.

ASSESSMENT OF EXISTING INFORMATION

The information collected and reviewed in this study serves as a basis of assessing the state of the art in emergency water planning. One indicator of the available information is the contents and the number of publications pertaining to emergency water planning. A total of about 2,000 publications were screened for subject areas related to this study. About 500 publications were evaluated for possible inclusion in the annotated bibliography, of which 133 publications were selected as relevant entries. The literature search covered the years 1945 to 1986. About 85 percent of those selected for annotation have been published since 1973, and about 30 percent are dated 1983 to 1985. Seven relevant publications were published during the 1960s and ten appeared during the 1950s.

In terms of content, 103 annotated studies provide various types of emergency planning guidelines and 48 publications (mostly overlapping) describe emergency case studies, primarily earthquakes, floods, and hazardous material spills. Nine publications consider various conceptual frameworks for emergency water planning. Three subject categories--engineering and design, damage assessment systems, and security aspects--appear less frequently. Overall, the literature is dominated by "How to...?" articles and emergency case studies.

The profile of emergency water planning literature suggests that the existing knowledge is primarily based on the "lessons learned" and "desk-top" considerations of a considerable number of authors. Sections which follow summarize the current knowledge in selected major elements of emergency water planning.

Emergency Planning Guidelines

Planning for water emergencies requires knowledge of the potential impacts on water services. This in turn requires identification of the characteristics of each hazard and the vulnerable components of human systems. Only a few authors made an attempt to provide a comprehensive conceptual planning framework for the development of emergency water plans. Formal emergency plans are either hazard specific or all encompassing with no specific consideration of the range of hazards to which they may apply.

The guidelines for the formulation of federal and state plans place emphasis on establishing legal authority for responding to a disaster. At the utility level, the major emphasis is placed on the development of effective emergency operations plans to provide for fast recovery from disaster damages. The most frequently considered elements of such plans include (1) establishing emergency communiciations; (2) training of the personnel; (3) preparedness through strengthening of various physical components of the system; and (4) preparation of formal plans that would be available in a written form. In terms of emergency planning concepts, these guidelines are focused primarily on preparedness and response phases. Little attention is given to hazard mitigation and recovery.

Engineering and Design

Disaster-resistant engineering and design aspects are discussed in 34 publications. Seismic design and redundancy and reliability are considered most frequently. Other design aspects found in the literature pertain to extreme weather conditions, interagency connections, and telemetry and remote control.

Several studies focused on ground failure as a major cause of earthquake damage. The relevant finding is that most earthquake-induced ground failures are caused by liquefaction, by strength loss in sensitive clays by soil, and rock slides on steep slopes. The seismic resistant design recommendations usually use nonbrittle pipe with flexible connections for both mains and service lines, using flexible lining for reservoirs and smaller capacity above-ground tanks. Also, the use of alternate routes for major water aqueducts away from fault zones and unstable ground is often recommended. Other measures include (1) maintaining standby engine-driven pumps; (2) providing backup treatment facilities and auxiliary power generators; and (3) maintaining stock of tools, excavating equipment, trucks, and repair supplies.

Engineering design resistant to the impacts of hazards other than earthquakes pertains primarily to floods, hurricanes, and cold weather. Telemetry and remote control facilities are considered useful for quick response to system failures in order to prevent secondary damages such as loss of pressure in the unaffected portions of the network. Finally, the literature contains several theoretical papers addressing the optimal redundancy of system designs and the levels of reliability that can be achieved.

Emergency Damage Assessment Systems

Emergency damage assessment systems were evaluated in terms of their applicability to water system emergency planning. The review of the literature revealed several studies on how water systems have performed in a large earthquake; little information was found on the vulnerabilities of water systems to other hazards. Although water utilities appear to be aware of their vulnerability, the overall state of knowledge regarding the potential direct losses incurred by the utility (transmission, treatment, storage, and distribution facilities) and the indirect losses measured by the impacts of the outage on the service region is modest at best. It seems that the indirect losses and employment effects produced from water supply interruptions are probably overstated in many studies.

Past disaster experience shows that direct losses to water systems seldom amount to more than 5 percent of aggregate damages to all systems and structures. It seems reasonable to assume that if the water outage lasts less than five weeks and amounts to no more than 40 percent reduction in supply, it will be difficult to observe any significant or measurable losses. Sizable economic losses are likely to be sustained as a result of disasters on the scale of the 1906 San Francisco earthquake or a major nuclear explosion. Several researchers attempted to assess the effects of truly catastrophic events on regional and national economics by applying a variety of simulation techniques since the experience with extraordinary earthquakes and nuclear war is limited.

Lessons Learned from Emergency Events

The case studies documenting actual responses to water emergencies often provide valuable illustrations of the critical elements of emergency preparedness and response. Such elements include the need to conduct a thorough hazard vulnerability analysis and to develop emergency plans that recognize the risk of various disasters. For example, the Anchorage Water and Wastewater Utility has adopted a formal Disaster Response Plan that evolved on a hazard vulnerability analysis that was initially recognized following the Great Alaska Earthquake of 1964. Typically the recommendations which stem from the earthquake experience draw attention to the value of maintaining auxiliary water supplies and stores of equipment and materials to facilitate emergency response and recovery. These elements were included among the key lessons learned following the San Fernando and Managua earthquakes.

Another recurrent group of recommendations pertains to the emergency operations planning at the utility level. These include:

(1) Maintenance of independent backup generators and the equipment (and procedures) for prompt testing of water for contamination after a disaster.

(2) The development of interagency coordination between water utilities and potential emergency support services, e.g., maintaining direct telephone lines with electric utilities so that power is restored without unnecessary delays.

(3) The need to conduct emergency training and cross training of the personnel to ensure the knowledge of emergency procedures and the technical features of a water supply system.

(4) Advanced assignment of specific emergency tasks and responsibilities in order to alleviate frequent breakdowns of communication lines during past emergencies such as the problem of inoperable radio base units during hurricane Alicia in Houston.

The lessons learned from many small- to medium-scale disasters may also serve to identify critical elements of a large-scale disaster impacting national security. One of such lessons points to the fact that the biggest water problem facing the U.S. during a major disaster will be the effective distribution of water to individual users rather than the provision of bulk water sources and portable treatment units.

RESEARCH NEEDS

General Recommendations

Emergency water planning information reviewed in this study suggests that there are numerous areas of inquiry where additional research is needed. In general, there is substantial need for continued research concerning the risk assessment and technical knowledge of the potential outcomes of interaction between the hazard and the major water supply systems. Useful means for evaluating mitigation effectiveness for both natural and man-made disasters need to be developed in order to permit more comprehensive benefit-cost studies of alternative techniques for hazard mitigation as compared with the costs of response and recovery. Without improvements in the determination of risk, water supply entities are unable to assess the economics of risk management in order to further reduce the chances of lengthy shortages in water supply. For example, there are no nationally accepted standards for the design of water storage, transmission, treatment, and distribution systems that would optimize their vulnerabilities to hazards other than earthquake.

There are numerous areas of research that pertain to specific aspects of emergency water planning such as (1) monitoring water sources and systems for early warnings; (2) developing better hydraulic and hydrologic models of major rivers and lakes for predicting the variability in water quality and quantity; and (3) developing effective communication channels to eliminate the potential for misinforming the public and to enhance public involvement in mitigation and prevention measures.

The recent nuclear accident at Chernobyl has exposed major inadequacies in national and international risk management systems. The major contention of this study is that despite increased activities in the area of emergency water planning in the United States, there still exists a policy vacuum between the federal or state governments and the local or regional planning efforts aimed at the protection against major natural and man-made disasters. Although states such as

California and New York seem to place proper emphasis on emergency planning, numerous other areas of the country seem unaware of the present and future potential losses posed by various disasters.

Recommendations for Federal Emergency Planning

It is clear that the federal government can neither plan for all contingencies nor can it provide aid to all disaster-stricken areas that experience difficulties in their ability to supply water. Nonetheless, the economic and social fabric is growing increasingly vulnerable to both man-made and natural disasters of a large scale, especially catastrophic events. More imaginative strategies are needed to determine the effects of such events on the human systems including regional and national economies.

There appears to be a substantial potential for truly catastrophic events that would require federal involvement in crisis situations in order to prevent sizable economic losses which would be sustained if federal aid is withheld. The current status of emergency planning at state and local levels shows that there is a great need for federal emergency water planning. Although such planning can draw on the existing knowledge in nonfederal emergency planning experience, a substantial body of information has to be generated to accommodate planning for national emergencies.

The recommended steps for the determination of the desired characteristics and elements of federal emergency planning are:

(1) Provide a forum to encourage discussion and debate of critical issues in federal planning for water emergencies by the scientific and engineering communities. This study might be distributed to national experts in various areas pertinent to emergency planning who would be asked to prepare papers for a symposium. There is a need to develop national emergency scenarios that are not based on the "extension" of localized disasters to the entire country.

(2) Develop a framework to evaluate the need for regional emergency plans. Water resources which remain under federal control in some critical regions of the country may be made an integral part of a plan for provision of emergency supplies. An investigation into the logistics of storing, transporting, and distributing water, decontaminating supply sources, and other emergency management activities may need to be undertaken.

The above are initial steps that may result in a better understanding of the needs and characteristics of the federal emergency water plans. Additional guidelines will be needed for the preparation of formal plans that would contain consistent procedures for providing federal assistance during national emergencies.

TABLE 1

SUMMARY OF STATE EMERGENCY WATER PLANS
CATEGORIZED BY MAJOR DISASTER PHASE

State	Response not Received	No Existing Plans	Major Disaster Phases Preparation	Response	Recovery	Mitigation
Alabama		X				
Alaska			X	X	X	
Arizona		X				
Arkansas				X		
California			X	X	X	X
Colorado			X	X		
Connecticut			X	X		X
Delaware			X	X		
District of Columbia			X	X		
Florida			X	X		
Georgia			X			
Idaho		X				
Illinois			X	X		
Indiana	X					
Iowa				X		X
Kansas						X
Kentucky			X	X		
Louisiana	X					
Maine			X			
Maryland			X	X		

TABLE 1 (Continued)

State	Response not Received	No Existing Plans	Major Disaster Phases Preparation	Response	Recovery	Mitigation
Massachusetts		X				
Minnesota		X				
Mississippi			X	X		
Missouri			X			
Montana	X					
Nebraska			X	X		X
Nevada				X		
New Hampshire				X		
New Jersey			X	X		
New Mexico				X		
New York			X	X	X	X
North Carolina				X		
North Dakota		X				
Ohio			X			
Pennsylvania			X	X		X
Rhode Island			X			
South Carolina			X	X		
South Dakota			X			
Tennessee			X	X		
Texas			X			
Utah			X	X		
Vermont	X					
Virginia			X			
Washington			X			
West Virginia			X	X		
Wisconsin	X					

II. FEDERAL AND STATE LAWS ANL REGULATIONS FOR EMERGENCY WATER PLANNING

II. FEDERAL AND STATE LAWS AND REGULATIONS FOR EMERGENCY WATER PLANNING

INTRODUCTION

Planning for natural or man-made hazards requires the identification of potential impacts on water services in the event that a disaster occurs. Russell (1978) noted that such knowledge must include not only an identification of the characteristics of each hazard and associated human systems (i.e., health, housing, industrial and commercial enterprises, the economy, and others) on which the hazard can inflict costs, but must also include a risk assessment and an understanding of possible outcomes of the interaction between hazards and human systems.

Even if optimal conditions exist for the development of comprehensive and well-coordinated emergency water plans, the plans alone are insufficient to cope with potential disasters. The emergency water plans must be backed by law or executive regulation; without such legal authority, the administering agency might be subject to suits brought by parties "injured" as a result of implementation of the plans. For example, the issuance of temporary permits or emergency rationing may be an expedient remedy to a water emergency and follow exactly in accordance with a particular emergency water plan. However, unless the plan is formalized and made legally binding, government officials may be held accountable for damages resulting from the restrictions on water use. Economic losses to existing water users, such as manufacturing shutdowns, large-scale crop damage, recreational prohibitions, and the like, may require compensatory payment if legal foundations for the plan do not exist.

Conversely, developers of emergency plans may be impeded by cumbersome, overlapping, site-specific water laws and regulations from multiple political jurisdictions. An immediate task in emergency water planning (EWP) is thus to identify the strengths and weaknesses of existing water laws and disaster-related policies. Planners need an integrated guide to assist them in answering key questions during the early stages of formulation of an emergency water plan, such as: What is contained in federal and state water laws or regulations and how do state water laws differ from each other? How do adjoining states work together to make their water laws compatible and effective for dealing with water-related emergencies? Are state or interstate emergency water plans coordinated with federal needs, priorities, and assistance plans?

TASK PURPOSE AND RESEARCH METHODS

This chapter presents the results of a compilation and review of federal and state laws and regulations pertaining to emergency water planning and assistance. Initially, relevant federal and state water laws were collected and evaluated for tangent features. In addition to the literature review, a variety of sources were contacted including the Corps of Engineers, the Federal Emergency Management Agency, state water resources research institutes, state water resources agencies, and state emergency management agencies. Initial and follow-up letters (when required) requesting information concerning emergency water planning activities were sent to water resources entities in 53 states and possessions. Of the states contacted, 50 have responded to date. Contents of the letters used in the survey are furnished in Exhibit A. The cooperation of the officials who responded to the requests for information is greatly appreciated.

Federal and state emergency laws were assessed in terms of their general emergency water requirements, their intra- and interstate provisions and coordination requirements, and their relationship with various federal emergency water plans or requirements. The following discussion further details this assessment and is supported by a series of tables to which planners may easily refer.

BASIC ISSUES OF WATER LAW

Generally, water law is a compendium of all rules of conduct which have been established to resolve water use conflicts and to guide water use decisions toward the goal of maximizing benefits to society (Cox, 1982). As water law evolved, many cases were initiated under crisis conditions, demanding resolution of a specific water resource management problem. The existing body of water law is not well ordered, integrated, or uniform, due in part to its variety of functional areas (supply allocation, proprietary rights, water quality, emergency assistance, and others). Furthermore, the two doctrines of water law, riparian and prior appropriation, which have divided the United States regionally into an East and a West respectively, may require different rules for the same functional area. Finally, water law has been further disaggregated by water source: surface water, groundwater, and diffused surface water. Detailed consideration of these aspects of water law is provided in the literature (Cox, 1982; Sax, 1968).

Water resource management has long recognized property rights as fundamental in realizing the greatest benefits from the resource. Private rights to water, exemplified by permits under the prior appropriation doctrine and by ownership of land bordering a watercourse under riparian law, are traditionally fixed and protected by state law and encourage investment in water-related development. On the other hand, federal powers are exercised to control commerce on navigable waterways and to reserve certain water rights through the proprietary clause of the United States Constitution.

Statutes supporting emergency water activities at the federal and state levels may have been created as exigency statutes modifying private water rights or as general emergency or civil defense statutes. Institutional frameworks for administering statutory powers include such mechanisms as (1) a single administering agency; (2) a combination of agencies with specific, nonoverlapping responsibilities controlled by the Office of the Governor; or (3) gubernatorial powers executed upon a declaration of disaster. Despite the existence of such complex legal and institutional arrangements, Hrezo, Walker, and Bridgeman (1984) indicate that water emergency management problems may remain unsolved if emergency statutes are not integrated with a general water management policy that incorporates disaster mitigation planning.

An established legal authority for implementing emergency water plans facilitates the application of planning resources across time and mediates the transfer of responsibility across successive government administrations. However, such laws, while providing stability, are not intended to preclude revision or refinement of the contents of the plan. The legal adoption of emergency water plans is also important to assure water users that planned apportionment features will indeed occur so that they can prepare accordingly to reduce potential impacts. For example, knowing that the act of rationing water is stipulated by law may promote an anticipation of rationing among water users. Administrators are thus expected to administer the emergency provisions of adopted water law.

Emergency water plans set by law enable governmental units to protect societal health and welfare through the orderly enactment and enforcement of emergency provisions. The establishment of a procedural routine designed to provide an orderly response under crisis is essential to efficiently distribute emergency supplies, to effectively bring aid to victims, and to prevent further loss of property or health.

Thus, it is imperative that pertinent federal and state water laws be asssessed to determine the content and coverage of existing mandates. In this way, inadequacies can be revealed to federal planners to facilitate their efforts to develop emergency water plans for national security disasters. It is hoped that the following analysis will identify areas for improving the legal foundation for emergency water planning.

DISASTER PLANNING PHASES

In order to categorize existing federal and state laws pertinent to emergency water planning, an evaluative framework must be established to provide a means of measuring planning comprehensiveness. Russell (1978) reviewed four phases of management activity (mitigation, preparedness, response, and recovery) conducted by various levels of governments on behalf of all natural and man-made hazards. These major planning components and their integrated relationships were first introduced in the Comprehensive Emergency Management (CEM) program of the Emergency Preparedness Project (1978) of state government emergency preparedness.

Mitigation

Mitigation refers to measures prescribed to avoid the incidence and intensity of a hazard before it impacts human systems and becomes a disaster. Such actions are expected to reduce the probability and extent of the damage and injury resulting from a water-related disaster. Mitigation is directed at modifying the hazard or the human systems with which the hazard may come into contact. Moderating the potential effects of a natural hazard is difficult due to current limitations on predicting the actual location of occurrence and event intensity. The adverse impacts of man-made hazards, such as toxic materials, may be relieved through public awareness programs and through stringent controls on purchase and distribution.

This long-term planning phase establishes preventive measures to minimize hazard damage, such as flood protection devices (dams, levees, floodwalls, and diversion reservoirs). A combination of structural and nonstructural measures may be required to modify public perceptions of the hazard and to invoke public willingness to invest time, money, and other resources in hazard mitigation. Possible measures include land use management, disaster insurance, taxes, and loans or grants contingent on the adoption and enforcement of specific mitigation activities such as building codes or hazardous material controls. Public information may play an important role in mitigation through education and persuasion, particularly to gain support of emergency water legislation. When compared to recovery costs, public forums such as hearings and media campaigns are inexpensive and cost-effective.

Preparedness

Laws promulgated to support water emergency preparedness would structure the contingency organizations empowered to operate in the event of a water disaster. Minimum organizational components would include teams to perform damage assessment, to conduct emergency repairs to water-related technology, to distribute emergency supplies, to maintain order and enforce crisis restrictions, and to continuously inform the public of developing disaster conditions. Preparedness planning produces the emergency operations order, a written and well-disseminated document that details readiness to act if confronted with a water disaster. The short-term actions of preparedness planning complement long-term mitigation measures.

Russell (1978) addressed three subprocesses of preparedness: (1) an integrated disaster-loss data base; (2) training for, and certification of, emergency managers; and (3) funding for integrated community warning systems. Although data bases have been created to list emergency personnel and equipment resources, data collection methods and methods for assessing disaster-related dollar losses have not been developed. Such methodology could yield valuable planning refinement by sorting actual needs from the perceived and often biased needs of special interest groups. Professional training for emergency managers provides a medium for the exchange of new ideas as well as an opportunity to learn the best approaches currently available. Finally, an early warning system that can be triggered to warn communities of an impending disaster is implied in the concept of preparedness. Such an alarm must sound horizontally through public media alerts as well as vertically through the hierarchy of government. This integration of early warning systems could mobilize maximum emergency resources with which to confront a water emergency.

Response

Response measures represent the ability to operationalize preparedness planning. Reaction to a water disaster requires the execution of emergency plan provisions to mobilize equipment, personnel, emergency communications networks, and management organizations. Emergency water plans are of little consequence unless their goals can be achieved through effective implementation.

Response assurance comes from rehearsals to test preparedness capabilities. Exercises designed to flex emergency warning and communication links among reacting units will reveal weaknesses that can be corrected through improved coordination strategies. Similarly, emergency water treatment equipment and transportation assets for hauling emergency water supplies can be inventoried to determine if contingency requirements are being maintained. Organizational weaknesses will also surface during these tests, particularly if responsibility has been placed on individuals without backup assignments being made.

Response planning dictates the level of reaction (local, state, federal, or a combination of these) to water disaster situations. Tailoring the response to meet specific emergencies can conserve the resources of the response organization and may result in a more rapid and efficient return to normal conditions. Too many response players can create confusion regarding which agencies are to perform what measures during a water emergency. Rehearsals and exercises designed to check response assignments are helpful in identifying unnecessary layers of bureaucratic support or duplications of effort. Laws specifying reaction responsibilities bring clarity to emergency water planning.

In extreme situations where water service cannot be restored, the response plan may dictate evacuation. Evacuation liability involves the responsibility for relocating potential or actual disaster victims to safe areas. Related policy issues are discussed by Drabek (1984).

Recovery

The recovery phase of emergency water planning can be viewed as postevent activities to restore vital support systems (i.e., transportation, food, and water) to minimum acceptable standards or to a predisaster environment. This phase of disaster planning is quite costly and state governments may often be forced to ask for federal assistance. Legislation to support financial assistance through loans or grants should be clearly worded and advertised with explicit application procedures.

Recovery also embodies the revisions made to the emergency water plan to prepare it for the next disaster. This phase closes the planning cycle and begins the process again, but emergency planning can now proceed from valuable lessons learned. Officials at various levels of government need the authority to develop improved procedures for consideration and adoption; such power is bestowed through the mandate of emergency water law.

CRITERIA FOR EVALUATING FEDERAL AND STATE WATER LAWS

The four major phases of disaster planning discussed above represent a comprehensive strategy for the formulation of statutes at federal and state levels of government. An understanding of the timing and interrelationship of these phases is important to provide planners with an all-inclusive approach to the complex issues of emergency water management. Clear, well-defined, and legally-supported mitigation and prevention measures can decrease the time and cost of recovery and ultimately reduce the consequences of a disaster occurrence. Recovery operations which include a thorough critique of an implemented EWP can yield better ways of refining and supplementing mitigation and prevention policies for future versions of the EWP. Thus, the planning sequence can be viewed as cyclical, a continuous evaluation of procedures and provisions. The general process is depicted in Table 2.

Laws supporting this process bring permanency, predictability, orderliness, and enforcement powers to support emergency water plan implementation, but they require committed planning resources to sustain the dynamic planning sequence. The remainder of this section will categorize federal and state water laws according to the presence of features that align with the four major disaster planning phases. This approach will facilitate further analysis of emergency actions currently prescribed by existing water laws and permit the determination of strengths and weaknesses from a collective viewpoint.

FEDERAL EMERGENCY WATER LAWS

Federal laws relevant to emergency water planning can be grouped into five categories based on the water-related hazard to which they pertain: (1) general natural disaster laws intended to cover all water-related hazards without specification; (2) national security orders and directives; (3) flood control acts; (4) water quality hazard legislation; and (5) drought hazard laws and assistance programs. Each of these categories contain statutes assessed against the criteria of major disaster planning phases.

General Natural Disaster Laws

The Federal Emergency Management Agency (FEMA) directs and administers federal disaster assistance authorities under the provisions of the Disaster Relief and Assistance Act of 1974 (PL 93-288) as amended. Under this law, FEMA is authorized to coordinate the activities of federal agencies to provide disaster assistance and to direct any federal agency to utilize its available personnel, supplies, facilities, and other resources in providing such assistance as a result of a major disaster or emergency declaration. Any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, sandslide, snowstorm, drought, fire, explosion, or other catastrophe may be declared a valid emergency or major disaster by the President of the United States. The difference between these two terms lies in whether the hazard is threatening (emergency) or has developed into an actual disaster. Following a declared major disaster, the level of emergency services available to supplement state and local efforts is significantly greater than the federal support assigned to disaster relief organizations.

On the discretionary declaration of the president, the FEMA director assigns specific mission assistance to federal agencies through authority delegated to FEMA regional directors. These missions may include damage assessment or investigations of state requests for presidential declaration. Federal agencies may be called on to perform emergency work on public or private lands essential for the preservation and protection of life and property, including channel clearance, emergency shore protection, and clearing and removing debris and wreckage. Public water supply facilities may be restored or replaced and technical and engineering advice and services may be rendered (Office of the Chief of Engineers, 1983a).

These provisions are primarily supportive of recovery planning, i.e., effected after a disaster occurrence. A limited degree of declared "emergency" services may be construed as preventive measures, particularly engineering assistance to reduce the threat of an impending hazard. However, reaction time may be crucially limited and crisis management may prevail. PL 93-288 includes a specific provision that absolves the federal government from liability for claims based on actions or omitted actions by a federal employee or agency in providing federal disaster assistance under its authority (Federal Emergency Management Agency, 1983b). It is intended to provide a state of readiness to respond to and manage any type of emergency. It also aligns with the preparedness and response phases of emergency planning and includes the identification of material and human resources to react to water-related hazards and disasters.

This general natural disaster law establishes national policy for coping with a variety of disasters and a platform for further planning development by federal departments and agencies. Mitigation and prevention measures regarding water supply hazards are noticeably absent but may be found in the other four categories of federal water-related legislation.

National Security Orders and Directives

The National Security Decision Directive 47 (1982) sets forth principles and policies for emergency mobilization preparedness. It states that it is the policy of the United States to have an emergency mobilization capability that will ensure that government, at all levels and in concert with the private sector and the American people, can respond decisively and effectively to national security emergencies. Executive Order (EO) 11490 (1969) requires departments and agencies to prepare national plans and programs to attain an appropriate level of readiness with regard to the functions assigned.

Executive Order 11921 (1976) amended this earlier order and adjusted emergency preparedness assignments with respect to the organizational and functional changes that had since occurred in federal agencies. The director of FEMA is required to coordinate all emergency preparedness activities and functions of federal departments and agencies and to provide guidance and assistance for the performance of their functions. The United States Army Corps of Engineers (USACE) or other Department of Defense (DOD) elements, under the guidance of the Department of the Interior, were required to develop plans and programs to help meet emergency water requirements in watershed areas under their jurisdiction. In 1983, emergency water planning was transferred from the Department of the Interior and is currently assigned to the Corps through DOD.

Accordingly, USACE is charged with developing plans for the management, control, allocation, and use of the nation's water resources in cooperation with the federal departments and agencies having statutory or delegated water responsibilities. The Corps provides national leadership and coordination for federal EWP in the national interest during a major disaster. The Corps also coordinates emergency water resource planning at the state, interstate, and local levels through appropriate federal departments and agencies concerned with each phase of planning.

Definitions of emergencies implied by these executive orders are given by type, size, and role of government. Domestic and regional emergencies are generally managed by local and state authorities, receiving federal assistance and coordination only where authorized by law. Water emergencies impacting on the entire nation, particularly those related to national security such as conventional or nuclear war, are clearly the planning responsibility of USACE.

A national security emergency is any occurrence, including natural, technological, or other emergencies, which seriously degrades or seriously threatens the national security of the United States. Under this order, policy for national security emergency management is to be established through the National Security Council. The director of FEMA serves as an advisor, provides staff support on issues of emergency management, and coordinates the roles of federal departments and agencies and state and local governments. Each federal department and agency is to identify facilities and resources essential to national defense and security and national welfare; assess their vulnerabilities to national security emergencies; and develop strategies, plans, and programs to minimize loss and to assure continued provision of essential resource services.

The Corps is currently preparing an Interim Response System which will be used to fulfill the emergency water resource responsibilities assigned in EO 11490. The formalized plan will present the implementation process, specify response organizations and procedures, and establish an emergency water data base containing decision information and response procedures. A water claimancy system will provide the administrative mechanism for emergency water support. States will submit their requirements through appropriate claimant agencies to USACE for analysis. If the use of special authorities is necessary, USACE will determine priority ratings for critical claims consistent with national objectives and will delegate priority water rating authority to claimant agencies.

Emergency water planning for national security emergencies as prescribed by these directives reflects preparedness and response emphases. Mitigation planning would be difficult to define, given the nature and magnitude of the emergencies for which this EWP is intended. The recovery phase would be transfered as quickly as possible to state or regional organizations.

Flood Control Acts

The Flood Control Act of 1950 (PL 84-99) directs actions pursuant to flood and coastal storm emergencies (Office of the Chief of Engineers, 1983b). Specifically, the chief of engineers may authorize missions to include disaster preparedness, advance measures, flood fighting and rescue work, rehabilitation of flood control works damaged or destroyed by flood, protection or repair of federally approved shore protection works threatened or damaged by a coastal storm, provision of emergency drinking water, and drought assistance. Detailed implementing instructions are contained in Engineer Regulation 500-1-1 titled Natural Disaster Procedures.

Disaster preparedness includes a provision for a permanent emergency management organization with representation at all echelons of the Corps of Engineers. Additionally, PL 84-99 provides for an emergency fund to be expended in support of the mission actions which were previously identified.

Of particular interest to this study are the provisions for emergency drinking water and drought assistance. The 1974 Amendments (PL 93-251) provide that the chief of engineers, in his/her discretion, is authorized to provide emergency supplies of clean drinking water, on such terms as he/she determines to be advisable, to any locality which he/she finds to be confronted with a source of contaminated drinking water causing or likely to cause a substantial threat to local public health and welfare. Any community faced with a contaminated drinking water threat is eligible for assistance. This law pertains not only to flood hazards and disasters but to any threat or catastrophe that contaminates a water supply system. The emergency service is implemented for 30 days or until FEMA undertakes the provision of emergency water under its own authorities.

There are three preconditions that the community must satisfy in order to receive federal help under this law. State and local governments must make full use of their own resources including National Guard capabilities. This implies that the problem is beyond solution at the state level and that national resources must be tapped to provide relief. Secondly, the request for assistance must be signed by the state governor or Bureau of Indian Affairs for Indian tribal lands. Military bases and other federal reservations are excluded and are not eligible for assistance. Finally, a responsible Corps official must determine that the threat of an actual contamination of drinking water exists. Contamination is defined in one of three ways: (1) the water exceeds maximum contaminant levels established by the Safe Drinking Water Act of 1977 (PL 95-190); (2) the water supply is deemed the source of public illness; or (3) an emergency situation endangering health has developed and removal equipment has been made inoperable.

The contamination may be deliberate, accidental, or natural, and the distribution system can be publicly <u>or</u> privately owned. Furthermore, although the federal assistance must be applied to provide water for drinking, determination of the quantity of water and the means of distribution is the discretion of the responsible Corps official, who will consider the situational needs and the cost-effectiveness of providing various quantities of water. However, water will not be furnished to business for processes but only for employee personal needs. Suitable methods for setup, processing, and distribution include truck transport of water to emergency water points, distribution of bottled water, temporary connection of a new supply to an existing distribution system, installation of temporary filtration, or the use of military mobile purification units.

A number of emergency planning issues arise as a result of reviewing this law's power to bring assistance and its broad range of applicability. Does this statute create a dependence on federal support? Although it stipulates that local and state resources must be used fully, if resources have not been identified through local or state emergency water plans, crisis management at nonfederal echelons of government may not be able to react in time without further endangerment to public health. The law does not require state and local areas to develop and document their own emergency water plan, yet it expects these levels of government to exercise a range of potential solutions prior to requesting federal assistance. To assume that comprehensive EWP is on hand at the state and local levels is not acceptable, as evidenced by this study. Moreover, federal costs are not specified as reimbursable by local or state governments, which may be perceived as a strong disincentive to establishing local emergency water plans.

On the other hand, the responsible Corps official can deny assistance if there is evidence that possible solutions exist and should be attempted at the local or state level. This is a valid discretionary action; neither the individual nor the Corps is liable for the consequences of denying assistance. This potential nonaction by the Corps may stimulate EWP development at state and local levels to avoid potential repercussions due to insufficient planning and preparation.

Thus, the Water Resources Development Act of 1974 amends the Flood Control Act and encompasses the response and immediate recovery phases of disaster planning, although the thorough documentation of implementing instructions is indicative of preparedness planning as well. Recovery assistance is limited to a temporal (30 days) solution; long-term repair and restoration are nonfederal responsibilities.

Water Quality Legislation

An analysis of the emergency powers contained in federal environmental protection statutes (related to water quality disasters) is summarized herein. The laws include the Safe Drinking Water Act (SDWA) of 1974, the Clean Water Act (CWA) of 1977, and the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980.

The CWA (PL 95-217) further ammended the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and gives the administrator of the Environmental Protection Agency direct authority on receipt of evidence to bring civil suit to restrain any person causing or contributing to an emergency pollution occurrence. The emergency must endanger the health or welfare of persons which infers applicability to water supply sources.

The SDWA (PL 93-523) provides emergency measures parallel to those contained in the CWA but states explicitly that the contaminant must be present in or likely to enter a public water system. In order for the administrator to take action, he/she must ascertain that state and local authorities have not acted to protect the health of imminently endangered persons. In addition to civil action in the form of a restraining order or temporary injunction, the administrator may also issue orders which carry a penalty of not more than $5,000 per day in which such violation occurs or failure to comply continues.

CERCLA (PL 96-510) mandated the revision and republication of the National Contingency Plan, originally created by the Federal Water Pollution Control Act Amendments of 1972 for the removal of oil and hazardous substances from the waters of the United States. The original National Contingency Plan was specifically directed at hazardous discharge into the waters of the country and included (1) the assignment of duties and responsibilities of federal departments and agencies; (2) the authority to procure and store hazardous pollution control supplies and equipment; and (3) the establishment of a strike force trained, prepared, and available to respond to a waterborne hazardous substance disaster. The CERCLA amendments established a new section to the plan with procedures and standards for responding to releases of hazardous substances, pollutants, or contaminants from facilities which pose substantial danger to the public health or to the environment. Thus, the hazardous substance may be discharged on land or into the air. Priorities for responding to hazardous substances include the potential for contamination of drinking water supplies. The administrator of the Environmental Protection Agency is given the authority under this act to establish and publish guidelines for using the imminent hazard, enforcement, emergency response authorities, and other emergency powers of (1) the National Contingency Plan, (2) the Clean Water Act, (3) the Resource Conservation and Recovery Act of 1976 (PL 94-580), (4) the Toxic Substances Control Act (PL 94-469), and (5) CERCLA.

All of these environmental protection statutes pertain to some extent to each of the major phases of disaster planning. Preparedness plans are documented to provide rapid response and extended recovery. The laws may also bear on prevention and mitigation planning in that the enforcement and penalty provisions (i.e., civil suits, administrative orders, and fines) may act as a deterrent to prevent an environmental hazard from developing into a water supply disaster.

Three separate federal agencies are tasked with administering these laws: the Environmental Protection Agency, the Corps of Engineers, and the Federal Emergency Management Agency. The laws overlap in that emergency water planning may be duplicated by each of these agencies and, in the event of an actual disaster, may require immediate coordination to distinguish responsibilities. All three agencies can react given gubernatorial requests for assistance and an executive proclamation of an emergency or major disaster. There is a need for unification of these provisions with one agency given overall management authority.

Drought Hazard Laws and Assistance Programs

A thorough investigation of federal emergency assistance in the event of a drought occurrence has been performed in other studies by Wilhite and Wood (1985), Wilhite (1986), and Hrezo et al. (1984). The focus of this study is on hazards and threats other than drought; however, a brief overview of the drought contingency planning and assistance responsibilities of the Corps of Engineers is appropriate.

The Flood Control Act Amendments of 1977 (PL 95-51) authorize the Corps to provide emergency supplies of water and to construct wells in drought areas. The chief of engineers, on written request by a farmer, rancher, or political subdivision, may construct a well on a cost-reimbursable basis when nonfederal interests have exhausted reasonable means for securing necessary water supplies, including assistance and support from the Small Business Administration, the Farmers Home Administration, and the Economic Development Administration. Assistance to an applicant in the transportation of water by vehicle, small diameter pipeline, or other means may be allowed if it is determined by the secretary of the army that, as a result of the drought, the applicant has an inadequate supply of water for human and livestock consumption and that water cannot be obtained by the applicant. The transport of water will not be provided for irrigation, recreation, or other nonconsumptive purposes. Corps assistance will not include the purchase of any water nor the cost of loading or discharging the water into or from government conveyance. Implementing instructions are provided in Engineer Regulation 500-1-1.

Additionally, all Corps water managers having civil works responsibilities are directed to develop drought contingency plans on a regional, basin-wide, and project basis as an integral part of water control management activities. Guidance for the preparation of these drought contingency plans is contained in Engineer Regulation 1110-2-1941 (Office of the Chief of Engineers, 1981).

These Corps directives align with disaster preparedness and response planning. Drought contingency planning establishes a readiness to react during water shortages. Emergency well construction and transport of emergency water supplies are actions taken to reduce the damage produced by drought and should be components of a drought contingency document.

Summary and Evaluation

There exists an assortment of federal laws and executive orders that authorize emergency water activities in the event of a man-made or natural disaster. Table 3 presents these laws arranged to show the category of law and the applicable emergency water planning characteristics exhibited by each.

Laws categorized as general natural disaster laws are quite thorough in delineating the preparedness planning responsibilities and response requirements of various departments and agencies following a disaster. However, they do not directly address water emergencies nor are they disaster specific. On the other hand, emergency water laws categorized as national security directives and orders (EO 11490) assign water supply emergency planning to USACE for national security emergencies. This order does not apply to routine emergencies, which are normally the responsibility of individuals, the private sector, volunteer organizations, local and state governments, and/or specified federal departments and agencies acting pursuant to their own statutory or other authorities. This order, therefore, segregates national security emergencies from other natural and man-made disasters. Although preparedness planning is to occur simultaneously, the role of the director of the Federal Emergency Management Agency differs. The Disaster Relief and Assistance Act and Executive Order 12148 gives FEMA the authority to direct as well as coordinate other federal agencies in providing disaster assistance. Executive Order 11490 assigns an advisory as well as coordinating role to FEMA while specifically assigning planning responsibility for the management, control, allocation, and use of the nation's water resources to the secretary of defense.

This demarcation signifies that national security emergencies involving water resources will be planned, controlled, and coordinated at the federal level (the secretary of defense). Other disasters are to be monitored at the federal level with federal assistance to be provided only when local and state resources have been exhausted. Regardless of the disaster scenario, emergency water planning at the federal level depends heavily on the existence of effective state EWP to establish a basis for further activity.

Similarly, the Flood Control Act of 1950, amended by the Water Resources Development Act of 1974, authorizes the chief of engineers (at his/her discretion) to provide emergency supplies of drinking water upon a signed request from the state governor, provided that state and local governments make full use of their own resources. Again, the assumption is that state EWP exists to guide local and state response although it is not required that state EWP be available or implemented. The determination of whether or not state actions are exhausted must be clearly evident to the chief of engineers to prevent an inappropriate intervention. Although reimbursement for emergency water services is required from the state receiving assistance, the associated costs may not be sufficient to stimulate improved EWP. Thus, there appears to be the potential for state governments to devote planning resources elsewhere and to depend on federal assistance in the event of a water emergency.

Emergency water laws categorized as flood control acts also include mitigation planning in the form of hazard mitigation teams which are activated immediately following a flood disaster. The objective of these regional teams is to reduce or avoid federal expenditures by providing a coordinated intergovernmental and interagency approach in the immediate 15-day postdisaster period. The rapid development of flood hazard mitigation measures is the primary goal; however, measures to reduce the potential for water system emergencies are assumed to be included in this objective if water systems are threatened or incapacitated by the flood disaster.

Water quality legislation pertaining to emergency water planning exhibits the characteristics of preparedness, response, and recovery. Legislation authorizes the EPA administrator to prepare guidelines for the enforcement of water quality standards through court actions and emergency response requirements in the event of a hazardous release or the contamination of a water supply. Other emergency response authorities exist for the removal of oil and other hazardous substances from the nation's waters. Gubernatorial requests for emergency assistance to provide drinking water supplies following water system contamination are to be submitted to the Corps of Engineers under the authority of the Water Resource Development Act of 1974. However, cases involving deliberate or accidental contamination will be coordinated with the EPA for determination of liability and possible legal action.

Drought hazard laws and programs are discussed in terms of the provisions of the Flood Control Act of 1977. The expected preparedness posture includes drought contingency plans formulated by the Corps of Engineers. Response authority provides for emergency well drilling and for transport of emergency water for human and livestock consumption. Within all categories of federal emergency water laws, there is a noticeable lack of authorized or directed mitigation actions. This deficit may be attributed to federal expectations that mitigation planning is best accomplished at the local and state level where the complexities of water supply jurisdictions and political boundaries are best understood. As planning to reduce the impact of disasters on water systems is not directed by federal law, it is reasonable to accept this explanation; however, the assurance of mitigation activity requires an investigation of emergency water planning at state and local levels.

STATE EMERGENCY WATER LAWS

Emergency water planning is a valid issue in water resource management. The National Governors' Association (1978) has stated as the first of eleven fundamental principles for national water policy that states have the primary authority and responsibility for water management. The association has asserted that water management activities relating to water quality, water supply, groundwater, wetland protection, coastal zone management, and soil conservation should be clearly delineated by Congress as the primary responsibility of the states and their interstate agencies. They desire that federal policy recognize and respect the rights of the states to administer their individual water laws and manage their water resources.

The Council of State Governments (1981) reported on the states' demonstration of this water management capacity. The council suggests that states conduct a self-assessment individually and collectively to determine how well prepared they are to assume the responsibilities advocated by the governors. Among the questions which states should ask introspectively are the following:

> Are there logically structured organizations capable of planning and management responsiveness?
>
> Are state water resource and related resource management plans being prepared and are states participating in the preparation of interstate regional plans with which federal policies, plans, and projects are expected to be consistent?

This study provides an insight into the answers which states may offer to these questions regarding EWP. The existence of water laws or directives authorizing comprehensive emergency water planning would indicate state capability to accept the responsibility of water supply management. The absence of planning documents or pertinent legislation may suggest needs for improving their posture.

It is apparent that a primary force in the development of federal emergency water plans and related laws and directives is the potential for national security emergencies. Coordination with regional water management agencies and state governments exhibiting established emergency water plans would greatly facilitate the development of a unified national plan to cope with national security emergencies.

Requests for Information

The collection and assessment of state emergency water plans and authorizing laws was primarily accomplished through written requests for information to all state water resource entities and state emergency management agencies. The letters presented a brief discussion of the project purpose, requested copies of pertinent materials, and requested a point of contact for further communication. Follow-up letters were sent to nonrespondents and supplemental phone calls were made to complete the contact effort.

All 50 states replied to the request for information. Of the 50 states which responded, five states (Indiana, Louisiana, Montana, Vermont, and Wisconsin) telephonically indicated that documents would be forwarded but they were not received by the time this report was prepared. Thus, 45 states and the District of Columbia provided a written reply from one or more water management agencies and the respondents and contents of their written reply are summarized in Table 4. Our evaluation of state emergency water laws and directives is based on materials furnished by these agencies. Their support was essential to this study and their participation is gratefully acknowledged.

A summary of state emergency water plans with responsible agencies and legal authorities is shown in Table 5. Extractions made from furnished documents to align with the four evaluative criteria often required investigator interpretation. Many of the documents assessed during this study were explicitly related to one or more of the aspects of comprehensive EWP. However, there were pertinent documents that were characteristically vague; that lacked definition of terms and clear assignment of emergency planning responsibilities; and that contained fragmented or overlapping legislation. When possible, these problems were resolved through contact with state agency representatives.

The compilation and evaluation contained herein is not to be construed as a grading instrument with which to rate one state against another or to rank states based on the quantity of documents contributed. Some states have decentralized emergency water planning to the local or county level and have determined their role to be coordination in the event of an emergency. Other states have decided to centrally manage EWP and have prepared extensive plans. Many states do not have plans that relate directly to water emergencies but do have general disaster plans that would become effective in the event of a major water emergency. In some areas emergency water planning is under study, particularly in cooperation with Corps of Engineer district offices, and strategies for comprehensive planning are currently being reviewed. Moreover, there may be additional plans at the state level which were not submitted or were overlooked by respondents because they were not the principal authoring agency. Every effort was made within the practical limitations of research resources to obtain complete information, and the high response indicates the success of this endeavor. This study provides an invaluable overview of EWP at the state level and establishes a baseline inventory for future revision, as needed.

Mitigation Measures

Relieving the potential threat to public water systems from natural or man-made hazards may be best accomplished at the local level where zoning and building ordinances, water source and system protection measures, and public awareness programs are born. The seven states shown in Table 6 have chosen to include mitigation planning within their legislatively authorized EWP to supplement expected local measures. California, Iowa, and Kansas require local water conservation planning, primarily directed at reducing waste and water loss in an effort to prevent a water shortage situ[illegible] programs that dictate source protection are specified by Connecticut and New York. Vulnerability assessments specifically intended to determine measures necessary to provide various degrees of protection to drinking water supplies and systems are to be prepared in Nebraska and Pennsylvania.

Preparedness Measures

Twenty-nine states and the District of Columbia have documented preparedness measures as summarized in Table 7. Each of these states presents some form of preparedness plan and contingency emergency organization at the state level. Texas maintains a water emergency plan for nuclear attacks which could be revised to pertain to other potential water emergencies. The identified provisions are found in either statutes or in actual EWP developed as a result of legislation.

Fifteen states require local water supply utilities or governments to prepare and either have on hand or submit to state agencies a detailed plan for coping with potential emergency water requirements. The preparation and update of these plans differs among these states. Some states provide detailed guidance to local utilities regarding the expected content of their EWP while others do not, assuming that locally written plans will be sufficiently detailed. The expressed requirement to update local plans also differs among states. For example, Missouri requires a quarterly update of points of contact and telephone numbers as compared to Ohio which stipulates an annual revision only. On the other hand, West Virginia does not require an emergency water plan from a local water purveyor unless the water supplier has made an initial request for state emergency water assistance. Then a plan must be submitted within 60 days of the first occurrence or further requests will be denied.

Provisions for supplemental or replacement water supplies are prescribed in one or more of three measures: (1) complete lists of water supply sources, systems, service capabilities are being assembled (Connecticut) or are on hand (Alaska, Delaware, Maine, and New Jersey) in five states; (2) rationing or emergency allocation plans primarily designed to prepare for water shortages are available in Alaska, Delaware, Georgia, and New York; and (3) four states (California, Colorado, Delaware, and New York) authorize emergency agreements which call for mutual aid or cooperation between and among governmental units at the local or county level. Private enterprises are invited to participate in such agreements. Rationing plans and preexisting agreements contribute to a sense of certainty by establishing advance water use priorities and emergency sources of supply, allowing users with lower priorities to plan to absorb allocation consequences.

Customer or public notification plans are established by California, the District of Columbia, Illinois, and New Jersey. California and Nebraska have written reporting and warning networks that include agencies at the local, state, and federal level. These state-level plans support local emergency communications systems and may be invoked if the severity of a disaster so warrants.

Four states specify the locations of emergency water equipment sites and the names and telephone numbers of persons to be contacted to obtain these resources. The equipment includes generators, pumps, pipeline, and portable water purification units. In addition to this preparedness provision, Maryland and New Jersey also indicate locations of water-hauling trucks throughout the state. Technical assistance personnel may be provided to set up equipment or to analyze contaminated water. Maine and Delaware are prepared to conduct testing and water quality analyses and maintain written emergency disinfection procedures to serve as guidelines for local water utilities.

Only four states explicitly call for emergency water exercises or provide training guidelines for emergency personnel: California, Nebraska, New York, and Virginia. Nebraska requires that the exercise be performed at least annually.

Response Measures

Twenty-five states and the District of Columbia have documented provisions for responding to emergency water situations. New Hampshire reported that it is currently developing a response plan. In most of these states, the preparedness features discussed above are to be implemented upon notification of an imminent or actual water disaster. However, many states indicate response actions but do not furnish specific details in an EWP. For example, a state may indicate that it reserves the responsibility to coordinate responding agencies at the local, state, and federal levels, yet the names and phone numbers of emergency personnel may not appear in the EWP. Some states may have the authority to order emergency allocation of water supplies but do not specify priorities or emergency sources of supply.

A summary of response measures gleaned from available documents is shown in Table 8. Seven states express coordination responsibilities among all levels of reacting agencies. Three states, Nevada, North Carolina, and Tennessee, have enacted legislation which empowers the governor to take any necessary actions utilizing any reasonably available state resources to respond to a water emergency and return to predisaster conditions. Connecticut, the District of Columbia, Maryland, and Nebraska specify that response actions are local responsibilities resting with either municipal or county governments or water utilities.

Emergency communications networks are maintained in Florida, Illinois, and Oregon. Public notification of emergency water conditions and guidelines for media releases are structured in seven states. This measure may also include advisory notices throughout the response period and into recovery operations.

Response actions taken to provide emergency water supplies through state intervention, if necessary, are found in 12 states. Arkansas may allocate waters in an emergency following an accelerated public hearing. Iowa, Kentucky, Oklahoma, North Carolina, and South Carolina have immediate emergency permit powers or diversion authority, particularly during water shortages. Pennsylvania can issue temporary permits and provide truck hauling for emergency water supplies as required. Water hauling is also a response of California, Colorado, Florida, Mississippi, and New Mexico. California, Colorado, and Utah may implement water exchange agreements, either preplanned or newly initiated.

Seven states provide damage assessment teams to determine the extent of a water emergency, to produce cost estimates, and to furnish periodic assessment reports. These states include Florida, Mississippi, Nebraska, New Mexico, and West Virginia. New Jersey and New York specify that their teams will determine the status of response activities in order to alert federal agencies if needed. This feature may contain only those management requirements that are essential to control the emergency situation and thus may economize on response resources.

Recovery Measures

California, Alaska, and New York have written recovery measures within the EWP. These provisions, listed in Table 9, are directed at continuing damage assessment, completing emergency repairs, and scheduling permanent repairs. Major recovery operations are primarily the responsibility of afflicted communities, with supplemental recovery resources (technical assistance and funding) furnished by the state or by federal recovery assistance.

Summary and Evaluation

Information was sought and obtained from state water resource centers and emergency management agencies pertaining to state water laws or regulatory documents that contained emergency water planning provisions. Forty-five states responded with documentation which was subsequently evaluated against four major planning components. These planning components (mitigation, preparedness, response, and recovery) originated in the comprehensive emergency planning approach of the Emergency Preparedness Project of 1978. This study focused on emergency water plans other than drought contingency plans, which were included only if they covered other potential water supply disaster scenarios. Similarly, general disaster or civil emergency preparedness plans were recognized if they exhibited specific water supply emergency provisions. Ten of the reporting states were determined to be outside of this focus for these reasons or because they specifically indicated that state-level emergency water legislation or associated documents were not available.

The results of the analysis are summarized in Table 10 and show that 37 states and the District of Columbia have established authority to conduct emergency water planning. California and New York list provisions that fit all four of the planning criteria for comprehensive management of public water emergencies. Four states (Alaska, Connecticut, Nebraska, and Pennsylvania) align with three of the planning components while the remaining 31 states and the District of Columbia have planned for emergency measures in one or two of the categories. The absence of provisions for a planning category does not necessarily imply a deficiency in emergency planning. As discussed previously, many states require thorough emergency water plans at the local or regional level and may not perceive a need to reiterate similar measures in state plans.

States with no EWP may operate under the principal of do the obvious (or what can be done under existing law). When a water emergency occurs, action is taken on a case-by-case basis as the situation dictates under the general provisions of emergency assistance. This planning strategy may not be the most desirable approach yet its evolution can be accepted, especially among states which have not experienced emergency water situations in recent history or which have been successful in alleviating water emergencies through local contingencies and resources. One state commented that it would be unrealistic to outline a definite course of action for every conceivable emergency. Others who have experienced only water shortages characteristic of droughts have placed their planning attention on this type of water emergency only. It is also apparent that some states have not planned for water emergencies and depend on existing riparian or appropriation doctrine and court adjudication to resolve emergency water needs.

It is certainly feasible that existing single-emergency state plans or general emergency assistance plans could be modified to specify a complete range of potential water disasters. This expansion may already be authorized under existing statutes or may require supplemental laws in order to develop such plans. Federal incentives to stimulate emergency water planning could accelerate the process and can be found in the Safe Water Drinking Act (PL 93-523).

With the passage of this Act in 1974, Congress provided that to maintain enforcement responsibilities for water quality standards, a state must adopt and implement an adequate plan for the provision of safe drinking water under emergency circumstances. Little more has been promulgated on the federal level, however, save for a draft of some suggested guidelines for reviewing the adequacy of state emergency plans. On the other hand, the Federal Emergency Management Agency, the Corps of Engineers, and the Environmental Protection Agency are ready for mobilization during declared water disaster situations.

INTERSTATE EMERGENCY WATER COMPACTS

Interstate compacts are legally recognized by the U.S. Constitution to establish permanent arrangements among the states. A compact is a binding contract between states, endorsed by the Constitution, and reflects state statutory authority as well. As contracts, interstate compacts take precedence over state laws that may conflict with their provisions. They stand as the most compulsory instrument to establish formal cooperation among states. The Council of State Governments has prepared a listing of 34 compacts that pertain to interstate water management. These compacts are categorized as water apportionment, water pollution control, or water resources and flood control agreements. The reader may wish to refer to this report for a description of the objectives of each compact, member states and statutory citations, interstate agencies, officers and staff listings, and additional data.

Generally, these compacts do not address specific arrangements for cooperative efforts in the event of a water emergency other than water shortages requiring apportionment of mutual water resources. A number of the compacts, such as the Delaware River Basin Compact, the Great Lakes Basin Compact, and the Susquehanna River Basin Compact engage in comprehensive planning, development, and management of water resources, and emergency water planning activities could therefore be included within their charters. The Delaware and Susquehanna River Basin Compacts are worthy of special note. The federal government is actually a party with binding status similar to that of the member states. This provides a new option within the federal system for interstate cooperation and may be a useful approach to emergency planning for water emergencies related to national security.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

A compilation and review of federal and state laws and regulations pertaining to emergency water planning and assistance was conducted and the results were reported herein. The four major phases of disaster planning--mitigation, preparedness, response, and recovery--were used as the criteria for assessment of documents furnished by state and federal agencies. This study represents a comprehensive overview of these emergency water planning laws and related references and provides a basis for further investigation into methods for strengthening weaknesses in water management programs.

Federal laws related to emergency water planning were sorted into five categories: general natural disaster laws, flood control acts, water quality laws, drought hazard laws and programs, and national security orders and directives. Natural disaster laws are thorough in defining preparedness planning responsibilities and response requirements of federal departments and agencies following the occurrence of a natural disaster. However, they do not specifically address water-related emergencies and are intended to be usable contingency plans regardless of the nature of the disaster. Flood control acts provide response authority to the chief of engineers to provide emergency drinking water supplies upon gubernatorial request. Water quality legislation provides for preparedness, response, and recovery planning through guidelines established by the Environmental Protection Agency. Drought hazard planning exists at the federal level but was not the focus of this study.

Executive Order 11490 assigns water supply emergency planning to the secretary of the army for national security emergencies. Disasters other than those impacting on national security are to be monitored at the federal level where federal contingency plans are to be implemented to provide assistance when local and state solutions are exhausted. Regardless of the water-related disaster scenario, emergency water planning at the federal level depends heavily on the construct and potential effectiveness of state EWP to establish a baseline planning foundation for further development.

Therefore, the existence of water laws or directives authorizing comprehensive emergency water planning would provide an indicator of state capability to accept the responsibility of water supply management. Forty-five states submitted documents relevant to emergency planning of which 35 states were found to have authorities relevant to water emergencies other than drought. Approximately 60 percent of the states have preparedness or response provisions applicable to emergency water planning. Only two states have adopted planning measures that align with all four categories of comprehensive emergency management planning. The absence of planning documents or authorizing legislation suggests a need for improving the emergency water planning posture at the state level. Frequently, states depend on local contingency plans which are assumed to be sufficient to cope with potential water disasters and historically may have appeared to be quite capable of doing so.

Although this strategy may be appropriate for limited emergencies contained within municipal or county boundaries it will not suffice in the event of a major catastrophe, particularly a disaster event involving national security. If states are to honor their commitment to the management of their water resources, they must organize and plan systematically to manage water emergencies at the state level and to contribute to the national security planning effort.

Additional incentives may be needed to stimulate state planning efforts. The Corps of Engineers district offices may be the most suitable source for planning guidance to assist states in preparing state-wide emergency water plans. It should be recognized that each state may have unique legal constraints that may hinder a neat universal approach. Yet, the potential severity of a national water emergency dictates that cooperative exchanges and planning milestones be established in the short term.

TABLE 2

CRITERIA FOR EVALUATING FEDERAL AND STATE WATER LAWS:
COMPREHENSIVE EMERGENCY WATER PLANNING

Planning Phase	Planning Setting and Related Major Activities
I. Mitigation and Prevention	Normal conditions: Recognition and identification of potential water supply hazards; evaluation of structural and nonstructural measures pertinent to each hazard; legal mandates to support selected measures.
	Emergency conditions: Monitor effectiveness.
II. Preparedness	Normal conditions: Establishment of emergency organization, warning and communication systems; designation of emergency funds, supplies, equipment and personnel; documentation and dissemination of emergency water plans; legalize foregoing arrangements.
	Emergency conditions: Monitor effectiveness.
III. Response	Normal conditions: Conduction of training exercises and gaming simulations; professional training of emergency management personnel; clarify liability rules for responders; adoption of laws to support these actions.
	Emergency conditions: Implementation of emergency water plan preparedness and monitor outcome.

TABLE 2 (Continued)

Planning Phase	Planning Setting and Related Major Activities
IV. Recovery	Normal conditions: Assessment of funding sources and amounts designated for temporary and permanent water system recovery. Evaluation of assignments for recovery operations. Emergency conditions: Commitment of continuing aid to return setting to normal conditions; critique of all actions taken and revision of emergency plan features to improve plan for future potential disasters; return to Phase I planning and revise existing water laws.

TABLE 3

SUMMARY OF FEDERAL EMERGENCY WATER LAWS AND DIRECTIVES

Emergency Water Planning Criteria	Category of Federal Emergency Water Laws: General Natural Disaster	National Security Orders	Flood Control Acts	Water Quality Laws	Drought Laws and Programs
Mitigation	PL 93-288	--	PL 84-99	--	--
Preparedness	PL 93-288	EO 11490 EO 11921	PL 84-99	PL 96-510	PL 95-51
Response	PL 93-288	EO 11490 EO 11921	PL 84-99 PL 93-251 PL 96-510 PL 94-580 PL 94-469	PL 95-217 PL 93-523	PL 95-51
Recovery	PL 93-288	PL 93-251	PL 94-469	--	--

TABLE 4

SUMMARY OF STATE RESPONSES TO REQUESTS
FOR EMERGENCY WATER PLANNING INFORMATION

State	Responding Agency	Documents Furnished
Alaska	Department of Military and Veterans Affairs Institute of Northern Engineering Water Research Center	--State of Alaska Emergency Plan of 1984
Alabama	Department of Environmental Management	--None (no prepared plans)
Arizona	Department of Water Resources	--None (no prepared plans)
Arkansas	Soil and Water Conservation Commission	--Arkansas Water Law --Rules for Surface Water Diversion Registration and Allocation in the State of Arkansas
California	Governor's Office of Emergency Services Department of Water Resources	--State of California Emergency Plan --Emergency Handbook for Water Supply Management --California Emergency Services Act --Natural Disaster Assistance Act --Health and Safety Code: Emergency Clean Water Grant Fund --General State Powers over Water (extract) --California Water Code (extract) --California Constitution (extract) --Proceedings Governor's Drought Conference (1977) --The California Drought (1976) --Drought: Alternative Strategies for 1978 --California Earthquake Response Plan --Water and Waste Disposal Systems
Colorado	Colorado Department of Public Health Colorado Water Resources Research Institute	--Policy Guidelines: Emergency Water and Sewer Assistance, Division of Local Government
Connecticut	Institute of Water Resources Department of Environmental Protection	--Connecticut Code Extracts --Public Act 85-535, Plan for Public Water Supply Coordination --Department of Health Services, Regulation on Coordinated Water System Plans, draft

TABLE 4 (Continued)

State	Responding Agency	Documents Furnished
Delaware	Water Resources Center Department of Public Safety, Emergency Planning and Operations Division	--Delaware Emergency Operations Plan, Utility Services Water Annex --Water Conservation Report --Letter to Bernard Dworsky
District of Columbia	Department of Public Works, Water and Sewer Utility Administration	--Metropolitan Washington Water Supply Emergency Agreement
Florida	Department of Community Affairs, Division of Emergency Management Department of Environmental Regulation (DER)	--Florida Peacetime Plan (extracts) --Florida Water Resources Journal (extract) --State of Florida Drinking Water Emergency Plan --Florida Water Resources Act of 1972 --DER Rule 17-108: EDB Remedial Grant Program --DER Rule 17-40: Water Policy --Florida Air and Water Pollution Control Act
Georgia	Department of Natural Resources, Environmental Protection Division	--Groundwater Use Act of 1972, as amended --Georgia Water Quality Control Act of 1977, as amended by the Surface Water Withdrawal Statute --Apalachicola-Chattahoochee, Flint Interim Drought Management Plan
Hawaii	Department of Land and Natural Resources, Division of Water and Land Development	--Civil Defense and Emergency Act Note: EWP being prepared in coordination with Pacific Ocean District, Corps of Engineers.
Idaho	Water Resources Research Institute in coordination with the Department of Water Resources	--None (no documentation on plans dealing specifically with EWP)
Illinois	Department of Transportation, Division of Water Resources Emergency Services and Disaster Agency	--Emergency Planning for Drinking Water Systems --Legal Responsibilities of Public Water Supply Officials --Proposed Illinois Pollution Control Board Rules and Regulations: Chapter 6, Public Water Supplies and Proposed Technical Policy Statements --The Illinois Emergency Services and Disaster Agency Act of 1975 with Amendments through 1983.
Indiana	No response as of September 15, 1986	

TABLE 4 (Continued)

State	Responding Agency	Documents Furnished
Iowa	Department of Water, Air and Waste Management	--The State Water Plan and 1985 Amendments --455B.266, Code of Iowa Rule 9900-52.7 implementing Iowa Code Chapter 455B, division III, part I.
Kansas	Kansas Water Office	--House Bill 270, Water Assurance Program Act --House Bill 2703 --Large Reservoir Management Section of the State Water Plan
Kentucky	Department of Military Affairs, Division of Disaster and Emergency Services Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection	--Letter from the Director of Operations --Water Resources Regulations, Title 401, Kentucky Administrative Regulations --Kentucky Revised Statutes (KRS), Chapter 151 --Water Rights in Kentucky, draft, DOW Research Paper
Louisiana	No response as of September 15, 1986	
Maine	Land and Water Resource Center, University of Maine at Orono	--Maine Revised Statutes, Volume 12, Title 22 --Paper entitled "Giordia"
Maryland	Department of Public Safety and Correctional Services, Maryland Emergency Management and Civil Defense Agency Forest, Park and Wildlife Services of the Department of Natural Resources	--House Joint Resolution #19 directing the Department of Natural Resources to undertake a study to develop state water resources --Extract from Maryland Standard Operating Procedures Manual (Tab C to Part 4) on Water Shortage
Massachusetts	Water Resources Research Center of the University of Massachusetts at Amherst	--Letter response
Michigan	Department of Resource Development, Michigan State University Department of State Police	--Letter response --Water Management in Michigan, Volume 5
Minnesota	Department of Public Safety Water Resources Research Center of the University of Minnesota	--Letter response
Mississippi	State Department of Health	--Mississippi Emergency Plan for Community Water Supplies
Montana	No response as of September 15, 1986	

TABLE 4 (Continued)

State	Responding Agency	Documents Furnished
Missouri	Department of Natural Resources	--The Missouri Safe Drinking Water Act and the Missouri Public Drinking Water Regulations
Nebraska	Natural Resources Commission State Civil Defense Agency	--Nebraska Revised Statutes, Section 84-162 to 84-167 --State of Nebraska Resource Crisis Management Study --Nebraska Disaster and Civil Defense Administration Natural Disaster Plan --Operational Resource Crisis Management Plan --Nebraska Emergency Safe Drinking Water Plan
Nevada	Department of Conservation and Natural Resources, Division of Water Resources	--Nevada Revised Statutes, Chapter 416
New Hampshire	Water Resources Research Center of the University of New Hampshire New Hampshire Water Resources Board Water Supply and Pollution Control Commission	--A bibliography of publications --New Hampshire Water Resources Management Plan (1984) --Drinking Water Regulations (1986)
New Jersey	Department of Law and Public Safety, Division of State Police, Emergency Management Section Department of Environmental Protection, Division of Water Resources	--New Jersey Safe Drinking Water Act (extracts) --New Jersey's Water Emergency, Sept. 1980-April 1982 --Guidelines for New Jersey Water Utilities for the Preparation of an Emergency Response Plan --Emergency Procedures: Responding to Potable Water Contamination from Hazardous Substances --Water Supply Emergency Response Plan --Report on the Trenton Water Crisis
New Mexico	Civil Emergency Preparedness Division of the Office of Military Affairs	--State Civil Emergency Preparedness Act --Memorandum of Understanding between the New Mexico Environmental Improvement Division and the Civil Emergency Preparedness Division, Office of Military Affairs
New York	Division of Militancy and Naval Affairs	--New York State Disaster Preparedness Plan --New York State Emergency Equipment Stockpile Instruction Manual --A Report on the 1985 New York City Drought
North Carolina	Department of Natural Resources and Community Development, Division of Water Resources	--North Carolina Statutes, Section 143-215
North Dakota	North Dakota State Water Commission	--Letter response

TABLE 4 (Continued)

State	Responding Agency	Documents Furnished
Ohio	Division of Public Water Supplies, OEPA	--Ohio Administrative Code 3745-85-01 through 3745-85-05
Oklahoma	Oklahoma Civil Defense Oklahoma Water Resources Board	--Oklahoma Revised Statutes, Chapter 6, Section 683.9 through 683.13, and Chapter 82, various section extracts.
Oregon	Water Resources Department	--Oregon State Statute, Chapter 401 --Oregon Water Laws --Final report to the Pacific Northwest Regional Commission on Oregon's Drought and Conservation Activities
Pennsylvania	Pennsylvania Public Utilities Commission Pennsylvania Emergency Management Agency Department of Environmental Resources	--Drought Contingency Plan for the Delaware River Basin --4 Pa. Code Chapter 118, Reduction of Major Water Use in the Delaware River Basin Drought Emergency Area --4 Pa. Code Chapter 11, Non-Essential Water Uses in the Delaware River Basin Drought Emergency Area --Assorted handouts
Rhode Island	Emergency Management Agency	--Department of Health Emergency Drinking Water Plan, draft, 1980
South Carolina	Water Resources Commission Military Department Water Resources Research Institute, Clemson University	--South Carolina Code of Laws, Article 3, Sections 48-43-510 through 620 --Drought Planning Response --South Carolina Water Law
South Dakota	Department of Military and Veteran Affairs, Division of Emergency and Disaster Preparedness	--Disaster Response Handbook
Tennessee	Water Resources Research Center, University of Tennessee	--Rules of the Tennessee Department of Health and Environment, Bureau of Environmental Health Services, Division of Water Quality Control --Tennessee Safe Drinking Water Act of 1983 --Tennessee Code Annotated (extracts) --Various Executive Orders

TABLE 4 (Continued)

State	Responding Agency	Documents Furnished
Texas	Texas Water Commission Texas Department of Health, Division of Water Hygiene U.S. Army Corps of Engineers, Southwestern Division	--Contingency Plan, Survival and Operations for Hurricane Conditions and Disasters, City of Corpus Christi --Texas Emergency Resource Management, Volume II
Utah	Department of Natural Resources, Water Rights	--Utah Water Law, Section 73-3-21 --Bear River Compact (Extract) --State of Utah, Emergency Operation Plans, Volume II, Natural Disaster --State of Utah Emergency Resources Management Plan
Vermont	No response as of September 15, 1986	
Virginia	Water Resources Research Center, Virginia Polytechnic Institute and State University	--Integrating Drought Planning into Water Resources Management (Natural Resources Journal article) --Code of Virginia, Section 44-146.1 through 44-146.18 --Special Reports Nos. 14 and 18
Washington	Department of Emergency Management Water Research Center, Washington State University	--Emergency Planning Workbook --Emergency Planning Instruction Guide --Rules and Regulations of the State Board of Health Regarding Public Water Systems --Planning Handbook--A Guide for Preparing Water System Planning --Washington State's Water
West Virginia	Water Research Institute, West Virginia University	--Standard Procedures for Drinking Water Emergencies
Wisconsin	No response as of September 15, 1986	
Wyoming	Wyoming Water Research Center	--Wyoming Water Law: A Summary

TABLE 5

STATE EMERGENCY WATER PLAN (EWP) AND RELATED LEGISLATION

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
Alaska	Appropriation	Dept. of Environmental Conservation Dept. of Military & Veteran Affairs	A complete scope of natural and man-made disasters	State of Alaska Emergency Plan of 1978. Provides a spectrum of enabling legislation
Alabama	Riparian	None	None	None
Arizona	Appropriation	None	None	None
Arkansas	Riparian	Soil & Water Conservation Commission	Water shortage	Act 81 of 1957 as amended by Act 180 of 1969
California	Appropriation & riparian	Governor's Office of Emergency Services (coordinating function)	State of war emergency State of emergency-complete range Local emergency	California Emergency Services Act of 1970 as amended in 1981-82 Natural Disaster Assistance Act of 1974 State of California Emergency Plan Health and Safety Code Water Code California Constitution General State Powers over Water
Colorado	Appropriation	Division of Local Government	Major health hazard due to sudden unplanned circumstances	General Disaster Emergency Act and Disaster Operations Plan; not state water law or regulation
Connecticut	Modified riparian	Dept. of Health Services, in consultation with the Dept. of Environmental Protection	Public water supply emergency to include contamination, power outages, drought, flood, or system failures	Connecticut Code Chapter 474, Section 25-32b and Chapter 446i, Section 22a-378.
Delaware	Modified riparian	Dept. of Public Safety, Emergency Planning and Operation Division	Major disruptions on disaster, war-caused, natural or technological (including war)	Delaware Code, Title 20, Part II, Chapter 31 Delaware Emergency Operations Plan, Annex N, Utility Services

TABLE 5 (Continued)

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
District of Columbia		Executive Director of the Metropolitan Washington Council of Governments	Water shortage emergency or water outage emergency	Metropolitan Washington Water Supply Emergency Agreement
Florida	Modified riparian	Dept. of Community Affairs, Division of Emergency Management (coordination responsibility) Dept. of Environmental Regulation (primary responsibility) Dept. of Health and Rehabilitative Services (identify contamination)	Hurricane, tornadoes, floods, and man-made disasters; short-term contamination of any type	Florida Peacetime Plan State of Florida Drinking Water Emergency Plan Florida Safe Drinking Water Act Florida Water Resources Act of 1972 DER Rules 17-40 and 17-108 Florida Air and Water Pollution Control Act
Georgia	Modified riparian (>100,000 gal per day dimension for other than agricultural purposes requires a permit)	Dept. of Natural Resources	Water shortage of surface waters; water contaminant of any type	Surface Water Withdrawal Amendment of the Water Quality Control Act of 1977 Water Quality Control Act of 1977 Ground Water Use Act of 1972
Hawaii	Appropriation with riparian considerations	Dept. of Land and Natural Resources, Division of Water and Lands Development		Plan is under preparation
Idaho	Appropriation	Dept. of Water Resources		No specific plan or statutes
Illinois	Riparian	Illinois Environmental Protection Agency, Division of Public Water Supplies with the assistance of the Emergency Services and Disaster Agency	Emergency loss of water to include poisoning, earthquakes, dam failures, mechanical failures, drought, etc.	Research and planning for drought management is ongoing The Illinois Emergency Services and Disaster Agency Act of 1975
Indiana	Riparian	No response received		
Iowa	Permit	Dept. of Water, Air and Waste Management and the Office of Disaster Services of the Iowa Dept. of Public Defense	Disaster emergency due to a drought or other event affecting the water resources of the state; a substantial local water shortage	Rule 900-52.7(2) and 455B.266, Code of Iowa

TABLE 5 (Continued)

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
Kansas	Appropriation and riparian	Kansas Water Office	Drought	House Bill 2703 and House Bill 2705 Large Reservoir Management Section of the State Water Plan
Kentucky	Modified riparian	Division of Water, Natural Resources and Environmental Protection Cabinet and The Dept. of Military Affairs, Division of Disaster and Emergency Services	Drought emergency or other similar situations; failure or incapacity of any dam, reservoir, levee, embankment, or other water barrier	Kentucky Revised Statutes (KRS) 151.200 and 151.297-299.
Louisiana	Riparian	No response received		
Maine	Riparian	The Dept. of Health and Welfare with the assistance of the Bureau of Emergency Preparedness	Emergency conditions and situations that may endanger the public health or welfare by contamination of drinking water	Maine Revised Statutes, Volume 12, Title 22, Section 2606
Maryland	Modified riparian	The Dept. of Health and Mental Hygiene, Office of Environmental Programs (emergency response planning) and Division of Water Supply, Dept. of Natural Resources and Maryland Emergency Management and Civil Defense Agency	Water shortage caused by drought, water system failure, or contamination of water supply	Maryland Standard Operating Procedures Manual of the Maryland Emergency Management and Civil Defense Agency
Massachusetts	Riparian	Dept. of Environmental Quality Engineering	Water supply emergencies	The Water Management Act of 1985, Chapter 21G of the General Laws
Michigan	Riparian	Great Lakes and Water Resources Planning Commission (ongoing study)	None	No emergency water plans
Minnesota	Modified riparian	No lead agency, planning is ongoing	None	Each county and municipality has an all-hazard Emergency Operations Plan
Mississippi	Riparian	Bureau of Environmental Health	Any condition where damage to water supply facilities is of such a nature as to allow the possibility of contaminants entering the system; also, a complete loss os system pressure	Not cited

TABLE 5 (Continued)

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
Missouri	Riparian	Dept. of Natural Resources	Emergency conditions	The Missouri Safe Drinking Water Act and the Missouri Public Drinking Water Regulations, Title 10, Division 60, Chapter 12
Montana	Appropriation	No response received		
Nebraska	Appropriation and riparian	To be delegated upon declaration of an emergency by the governor; the State Divil Defense Agency and State Dept. of Health	Vital Resource Emergency from any national or man-made cause	Nebraska Revised Statutes Sections 84-162 to 84-167 Nebraska Disaster and Civil Defense Act Operational Resource Crisis Management Plan Nebraska Emergency Safe Drinking Water Plan
Nevada	Appropriation	To be delegated upon declaration of an emergency by the governor	Water emergencies	Nevada Revised Statutes, Chapter 416
New Hampshire	Riparian	Water Supply and Pollution Control Commission	Not specified; requires emergency response plan of all communities with >500 population	Drinking Water REgulations (1986), Ws 307.08
New Jersey	Modified riparian	Dept. of Environmental Protection, Division of Water Resources	Any natural or man-made event which causes a water supply system to encounter a major disruption of its function; not normally occurring operational disorders	New Jersey Safe Drinking Water Act of 1977 Water Supply Emergency Response Plan
New Mexico	Appropriation	Governor declaration, Civil Emergency Preparedness Division through the Environmental Improvement Division	Disaster damage restoration	Memorandum of Understanding between CEPD and EID State Civil Emergency Preparedness Act Disaster Relief Act
New York	Riparian	State Disaster Preparedness Commission	Full range of natural or man-made conditions to include air/water contamination	New York State Constitution New York State Executive Law, Article 2-B as amended New York State Defense Emergency Act as amended New York State Interstate Civil Defense and Disaster Compact

TABLE 5 (Continued)

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
North Carolina	Modified riparian	Environmental Management Commission and Dept. of Natural and Economic Resources	Water shortage or emergency	North Carolina Statute 143-215.8A through 143-215.23 and 143-350 through 143-355
North Dakota	Appropriation and riparian	Disaster Emergency Services Agency	Drought and other water emergencies	North Dakota Disaster Act, Chapter 37-17.1
Ohio	Riparian	Director, OEPA or duly authorized representative	Emergency conditions	Ohio Administrative Code 3745-85-01 through 3745-85-05 Ohio Revised Code 6109.01; 6109.03; 6109.04
Oklahoma	Appropriation (stream water); correlative rights & property ownership (groundwater)	To be delegated upon declaration of an emergency by the governor	Civil defense emergencies	Oklahoma Revised Statutes, Chapter 63, Section 683.8 through 683.13
Oregon	Appropriation and riparian	Emergency Management Division of the Executive Department	Full range of natural and man-made events to include utility emergencies	Oregon Statutes, Chapter 401
Pennsylvania	Modified riparian	Dept. of Environmental Resources, Bureau of Water Resources Management Bureau of Community Environmental Control	Drought and water contamination, spills, accidents, natural disasters, or breakdowns in treatment	Interstate Drought Management Agreement Chapter 109 of Safe Drinking Water Regulations Public Water Supply Manual, part IV, Emergency Response
Rhode Island	Riparian	Dept. of Health, Division of Water	Quantity or quality of one or more drinking water supplies is adversely affected	Dept. of Health Emergency Drinking Water Plan, draft; no cited laws
South Carolina	Riparian	Dept. of Health and Environmental Control; Drought Response Committee	Drought	Drought Response Act of 1985
South Dakota	Appropriation and riparian	The governor through the Division of Emergency and Disaster Service, Department of Military and Veterans Affairs	Disasters caused by enemy attack, sabotage, or other hostile action, fire, flood, snow storm wind storm, tornado, cyclone, drought, earthquake, or other natural causes	South Dakota Codified Law 35-15, Emergency and Disaster Service, and and related authorizing statutes

TABLE 5 (Continued)

State	Water Law Legal Regime	Agency(s) Responsible for EWP	Types(s) of Emergencies	Legal References
Tennessee	Riparian	The governor through the Emergency Management Agency	Emergency circumstances	Tennessee Code; Annotated Code 68-13-710
Texas	Appropriation and riparian	The governor through Dept. of Public Safety, Division of Disaster Emergency Services and the Dept. of Water Resources	Nuclear attack or crisis relocation	Texas Disaster Relief Act of 1975 Executive Order of the Governor, No. 11 August 15, 1979 Texas Emergency Resource Management Plan
Utah	Appropriation	Chairman of the Water and Elective Power Section of the Utah Emergency Resources Management Organizations	Nuclear attack or national disaster	Not specified in available literature
Vermont	Riparian	No response received		
Virginia	Riparian	Department of Emergency Services	Threatened or actual disaster either natural or man-made	Virginia Code of Law, Chapter 3.2, Section 44-146.16 through 44-146.18
Washington	Appropriation and riparian	Dept. of Social and Health Services, Water Supply and Waste Section	Water emergency to include loss of service, escaping water, sudden changes in water quality	Revised Code of Washington 95.20.050.83-19-002 (Order 266) and Rules and Regulations of the State Board of Health Regarding Public Systems Section 248-54-195
West Virginia	Riparian	Office of Emergency Services	When unable to meet the minimum needs of customers, either resulting in health or fire hazard	West Virginia Code, Chapter 15, Article 5, as amended; Interim Plan for Emergency System Operations; WVC, Chapter 17, Article 2A-8, para. 8
Wisconsin	Riparian	No response received		
Wyoming	Appropriation	Not specified in available documents	Not specified	Not specified

TABLE 6

SUMMARY OF STATES WITH MITIGATION FEATURES WITHIN EWP STATUTES

State	Description of Mitigation Measures
California	Conservation of water resources through restrictions on riparian rights; provide preplanning guidelines to counties within the South San Andreas major fault system.
Connecticut	State directs preparation of EWP by public water utilities which includes discussion of land use plans as they relate to source protection and discussion of present and historic pollution sources which might affect sources of supply. Plans are to be updated as often as necessary but at least every five years.
Iowa	Water conservation is integral component of state water plan intended to reduce water shortage impacts.
Kansas	Water conservation plans and practices are required of applicants for permit to appropriate water.
Nebraska	Vulnerability analysis to determine measures necessary to accomplish various degrees of protection of drinking water supplies and systems and establish priorities for postdisaster operations.
New York	Specific compliance/enforcement programs, education and public awareness, land zoning/land use programs, prevention projects, policies, and programs.
Pennsylvania	Individual water utilities are provided guidelines for vulnerability assessment.

TABLE 7

SUMMARY OF STATES WITH PREPAREDNESS FEATURES WITHIN EWP STATUTES

State	Description of Preparedness Measures
Alaska	Assure that adequate planning, surveys, and studies are conducted on a continuing basis and that an up-to-date listing of water resource capabilities is maintained. Review rationing plans for possible implementation. Provide resource policy guidance to the executive group and selected emergency services staff for water resource allocation, distribution, and management to support emergency operations. Encourage, as requested by the executive group, resource management support among the private sector through information programs and emergency plans.
California	No person shall operate a public water system without an emergency customer notification plan in the event of imminent danger to the health of water users. Earthquake response plans at all county and most local levels that address water supply emergency; these plans establish emergency organization, guidelines for emergency procedures and training; establish response priorities, channels of communications at all levels; provide suggested content of desirable preemergency agreements, guidelines for practice exercises, and public information release; vulnerability assessment.
Colorado	Voluntary cooperative agreements have been executed with private owners of reservoirs for emergency acquisition of domestic and livestock water. State-owned reservoirs are also called on for emergency domestic and livestock water.

TABLE 7 (Continued)

State	Description of Preparedness Measures
Connecticut	Commissioner of health services may authorize or order the sale, supply, or taking of any water or the temporary interconnections of water mains for sale or transfer of water among water companies response to a declared public drinking water supply emergency. Includes penalties for noncompliance. Each water company must submit a plan and a strategy to meet needs through contingency procedures for public drinking water emergencies. Specific plan contests are specified by state regulation. The state is also formulating coordinated water system plans.
Delaware	State medical/health coordinator and local utility operators should perform water quality surveillance, have information regarding emergency water sources and delivery capacity, and arrange mutual aid agreements. A comprehensive water resource management plan exists for conjunctive water use/and maximum use of existing infrastructure.
District of Columbia	Regional EWP provides for emergency operations center public media information dissemination and contingency emergency water supply ordinance.
Florida	All community and noncommunity systems providing drinking water will prepare an emergency/disaster plan. A detailed drinking water emergency plan includes the following key provisions: vulnerability assessment, emergency operations planning, and security.
Georgia	Authority exists to regulate nonagricultural water use of over 100,000 gallons per day and establish priorities for competing water uses in an emergency situation, particularly a water shortage.
Illinois	Provides planning guidebook and checklists for community public water suppliers. Primary detailed planning is the responsibility of local/county water suppliers. The state will coordinate and release public statements to media.
Kentucky	Implement planned water conservation measures during water shortages.

TABLE 7 (Continued)

State	Description of Preparedness Measures
Maine	Emergency plans include potential sources of contaminants and situations or conditions that could place them in the sources of public drinking water techniques and methods to be used by public water systems to reduce or eliminate the danger to public health methods and times for analysis on testing during emergencies, alternative sources of water and methods of supply public drinking water to consumers if a public water service cannot supply such water.
Maryland	Plan specifies location of tankers for hauling potable water and location of emergency equipment such as pumps, generators, pipes, filtration units, and portable tanks. Technical assistance in setup of this equipment is also provided.
Mississippi	Plan specifies points of contact at state level and county level for reporting water supply emergencies.
Missouri	Water suppliers are required to prepare emergency operations plans which include quarterly updated telephone numbers of response personnel, evaluation of alternative water systems, an inventory of emergency equipment, and emergency disinfection procedures for trucked water.
Nebraska	Identification of emergency responsibilities, predisaster planning and training through annual emergency operations exercise, and communications management.
New Jersey	Provides a written guide for each water purveyor for preparing local emergency plan. State plan defines responsibilities, inventory of emergency equipment, tank hauling, technical assistance in locating alternate sources of water supply, and source evaluation assistance. The state will be prepared to communicate public service messages pertaining to the overall emergency situation.
New York	Identification and inventory of emergency supplies and equipment establish a reporting and warning system, prepare plans for resource allocation and mutual assistance, technical assistance, and training.

TABLE 7 (Continued)

State	Description of Preparedness Measures
Ohio	Each community water system shall prepare and maintain a written contingency plan for providing safe water to its service area under emergency conditions, updated annually.
Oregon	Established emergency telephone system and organization with responsibilities of Emergency Management Division.
Pennsylvania	Extensive written guide for water utilities on emergency response planning.
Rhode Island	List of key points of contact, updated inventory of public water systems, listing of tank truck firms.
South Carolina	Public water suppliers are required to have emergency water plans.
South Dakota	Required to prepare a comprehensive plan and program for the emergency and disaster service of the state, integrated and coordinated with federal and local plans (not water-specific).
Tennessee	All community water systems shall prepare an emergency operations plan in order to safeguard the water supply and to alert the public of unsafe drinking water in the event of man-made or natural disasters. A state plan for the provision of safe drinking water is to be developed for emergency circumstances.
Texas	Maintain emergency water resource plans to include distribution and use of water and the preservation and conservation of existing water supplies; be prepared to provide resource support for the operation of water utilities and suppliers within the state. Texas maintains a detailed emergency water management plan for nuclear attack emergencies that specifies response actions for immediate supply and continuing supply.

TABLE 7 (Continued)

State	Description of Preparedness Measures
Utah	Local government and local utilities are to develop a written disaster control plan based on detailed state guidelines.
Virginia	Be prepared to procure supplies and equipment to institute public awareness and training programs and to take all other preparatory steps in advance of actual disaster to ensure the furnishing of adequately trained and equipped forces in time of need (not water-specific).
Washington	State shall assist the water purveyor in establishing the level and content of operations programs to include emergency response. State has prepared an emergency planning workload and instructional guide for this purpose.
West Virginia	Local water purveyors must develop a water emergency plan no later than sixty days after their first request to the county for assistance. If the plan is not developed, future requests for aid will be denied.

TABLE 8

SUMMARY OF STATES WITH RESPONSE FEATURES WITHIN EWP STATUTES

State	Description of Response Measures
Alaska	Alert emergency resource management staff and Resources Priorities Board members and direct them to report for duty assignments. Assume the continuing supply and management of resources to support the population. Provide guidance to the Executive Group for the release of emergency public information urging public and private sector support for water resource management. Advise the Executive Group of actions and measures necessary to assume the availability of water resources to enhance survival and recovery efforts. Coordinate water resource management activities with the federal and local jurisdictions.
Arkansas	Allocation of water during shortages following a public hearing within compressed time frames, if emergency declared.
California	Water exchange agreements and water banking during drought conditions and earthquakes. Emergency Clean Water Grant Fund for emergency actions to ensure safe drinking water supplies from public systems.
Colorado	Water banking during drought; execute voluntary agreements with private reservoir owners and state-owned reservoirs.
Connecticut	Response measures are identified in public water supply utility EWP.
Delaware	Issue advisory notices to the general public on precautions to be taken to avoid human consumption of contaminated water during and after water supply disasters.
District of Columbia	Response is obligation of water supply utility.

TABLE 8 (Continued)

State	Description of Response Measures
Florida	Emergency communications, public media warnings, maintain full levels of water storage reservoirs and elevated tanks (when possible), coordinate with other state emergency agencies, survey damage and make cost estimates, prepare assessment report, and transport water if required.
Illinois	Coordinate support from federal assistance agencies if the scope of the disaster warrants federal support. Provide emergency service telephone listings to public water utilities; inform the public and provide instructions in the event of an emergency.
Iowa	Authorize emergency permits upon gubernatorial proclamation; conduct emergency allocation of water; emergency equipment such as electrical generators, pumping units, water purification units is supplied as required.
Kentucky	Temporary allocation powers and power to issue permits for interbasin transfer of water.
Maryland	Response planning is focused at the water supply water utility level in which reliable service must be demonstrated by interconnection with other supplies, with standby wells; by using reservoir storage; or by providing alternate water supply. Otherwise, plans must be prepared that demonstrate how water is to be supplied to users under emergency conditions. State plan emphasizes coordination of state, federal, and local response.
Mississippi	Water supply emergency is investigated by a team of experienced water supply personnel which will coordinate its activities with local and state agencies and direct notification of contamination to users. Long-term emergencies may require authorized water hauling.
Nebraska	Local response emphasis; state provides sanitary survey and technical assistance and coordinates emergency response and delivery of safe water. State plan will be updated annually.

TABLE 8 (Continued)

State	Description of Response Measures
Nevada	Governor has power to issue, amend, or rescind any regulation or order designed to alleviate or manage a water emergency and utilize the services, equipment, supplies, and facilities of any state agency or political subdivision of the state to the greatest extent practicable to meet water emergency.
New Hampshire	Community public water supply systems shall have a detailed formal emergency response plan filed with the state by December 31, 1987.
New Jersey	Response plan includes problem identification, case assignment and support group determination, investigation of contamination, classify source of contamination, response scope determination.
New Mexico	Damage survey and technical assistance; water hauling authority.
New York	Receive information and notify appropriate agencies; receive, verify, and evaluate damage assessment reports; determine appropriate level of response; prepare executive orders and news releases; and coordinate response actions.
North Carolina	Emergency dimensions of water and the power to make such reasonable rules and regulations governing the conservation and use of waters within the emergency area.
Oklahoma	Provisional temporary permits (60 days); emergency grants.
Pennsylvania	Emergency permit authority for construction, operation, or modification of a public water system; also emergency response bulk water hauling.
South Carolina	Authority to issue emergency transfer permits (interbasin).
Tennessee	Take such actions as may be deemed necessary in order to provide safe drinking water where it otherwise would not be available.

TABLE 8 (Continued)

State	Description of Response Measures
Utah	Immediate "postattack" needs are answered through interconnections with other systems or alternate means for satisfying a shortage, transfer equipment to correct deficiencies.
West Virginia	State actions include coordination of local and federal response, assist local suppliers in diagnosing and treating contaminated waters, alert public to actual and potential health dangers, keep news media informed.

TABLE 9

SUMMARY OF STATES WITH RECOVERY FEATURES WITHIN EWP STATUTES

State	Description of Recovery Measures
Alaska	Assess remaining resources and assist with the development of priority requirements for their utilization. Request federal assistance where state capabilities are exceeded.
California	Damage assessment, complete emergency repairs, and schedule permanent repairs (earthquake disaster).
New York	Coordinate state agency recovery assistance and arrangements to administer federal recovery assistance.

TABLE 10

SUMMARY OF PRINCIPAL FEATURES OF STATE EMERGENCY WATER PLANS
CATEGORIZED BY MAJOR DISASTER PHASE

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Alaska	Policy guidance on allocation; public info programs; data base maintenance.	Staff notification; public communication; advise Executive Group; coordination.	Continual assessment to establish work orders and priority and request Federal assistance.	---
Arizona	EWP at local levels.	---	---	---
Arkansas	---	Emergency allocation.		
California	EWP at local levels; public notification; organization defined; personnel training and exercises;guides for pre-emergency water agreements; vulnerability assessments.	Execute water exchange pacts.	Continual assessment of damage;emergency repairs; schedule	Water conservation; preplanning guides to locals.
Colorado	Voluntary acquisition agreements; State-owned reservoirs in contingency plan.	Water banking during drought; execute voluntary agreements.	---	---

TABLE 10 (Continued)

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Connecticut	---	As identified in public utility SOP.	---	Land use plans; identification of pollution sources
Delaware	Water quality surveillance; data base maintenance; mutual aid pacts; conjunctive water use plan.	Public communications.	---	---
District of Columbia	Organization defined; public info guidance; contingency supply ordinance.	Response at utility level.	---	---
Florida	EWP at local level; vulnerability assessment; organization defined; security planning.	Public communications; coordination; survey damage and make cost estimates; prepare assessment reports; transport water.	---	---
Georgia	Water use emergency priorities.	---	---	---
Illinois	Guidelines for EWP at local level; public info guidance.	Coordination; public communications.	---	---

TABLE 10 (Continued)

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Iowa	---	Emergency permits; execute allocations; provide equipment.	---	Water conservation programs.
Kansas	--	---	---	Water conservation programs.
Kentucky	Planned water conservation measures.	Temporary allocation powers; emergency permits.	---	---
Maine	Vulnerability asssessment; data base management.	---	---	---
Maryland	Data base maintenance; technical training.	Response at utility level; coordination.	---	---
Mississippi	Organization defined.	Public communications; coordinations; truck hauling.	---	---
Missouri	EWP at local level; data base maintenance.	---	---	---
Nebraska	Organization defined; training and annual exercise; communication plan.	Response at local level; sanitary survey and technical aid.	---	Vulnerability study to establish water supply protection.

TABLE 10 (Continued)

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Nevada	---	Gubernatorial powers.	---	---
New Hampshire	---	Response at utility level.	---	---
New Jersey	Guidelines for EWP at utility level; organization defined; data base maintenance; truck hauling plan; public info guidance.	Investigation and classification of contamination; determination of scope of response; prepare executive orders.	---	---
New Mexico	---	Damage assessment; technical assistance; truck hauling.	---	---
New York	Data base maintenance; communications plan; allocation plans and mutual assistance pacts; technical assistance and training.	Coordination; damage assessment; public communications; determination of scope of response; prepare executive orders.	Coordinate Federal aid and extended State assistance.	Compliance and enforcement programs; education and public awareness; land zoning/use programs; contamination prevention programs.
North Carolina	---	Emergency diversions; executive powers.	---	---
Ohio	EWP at utility level.	---	---	---

TABLE 10 (Continued)

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Oklahoma	---	Temporary permits; emergency grants	---	---
Oregon	Emergency telephone system; organization.	---	---	---
Pennsylvania	Guidelines for EWP at utility level.	Permit authority; truck hauling.	---	Guidelines for vulnerability study at utility level.
Rhode Island	Data base maintenance.	---	---	---
South Carolina	EWP at utility level.	Emergency transfer permits.	---	---
South Dakota	EWP required at State level; contents not specified.	---	---	---
Tennessee	EWP at utility level; State plan also required but contents not specified.	Gubernatorial powers.	---	---
Texas	Data base management; State plan on hand for nuclear attack.	---	---	---

TABLE 10 (Continued)

State	Preparation	Major Disaster Phases Response	Recovery	Mitigation
Utah	Guidelines for EWP at local and utility levels.	Execute system interconnections.	---	---
Virginia	Disaster training.	---	---	---
Washington	Guidelines for EWP at utility level.	---	---	---
West Virginia	EWP at utility level.	Coordination; technical assistance; public communications.	---	---

EXHIBIT A:

LETTERS TO STATE WATER RESOURCE CENTERS

Planning
& Management Consultants, Ltd.

808 West Main Street • P.O. Box 927 • Carbondale, IL 62901
(618) 549-2832

LETTER TO STATE WATER RESOURCES INSTITUTES

May 23, 1986

Dear :

The Engineer Institute for Water Resources, U.S. Army Corps of Engineers, has contracted with our firm to develop a comprehensive analytical bibliography on the topic of Water Supply Planning for Emergency Situations, followed by a detailed assessment of the existing knowledge and research needs in the emergency water planning (EWP) area. In this regard, I am writing to request your assistance in obtaining essential information which will be integrated into a sufficient guide to planners at the local, state, and federal levels.

I would be most grateful if you would provide us with the following information:

1. A copy of state water law or regulatory documents that contain emergency water planning or allocation provisions;

2. Copies of any intrastate or interstate agreements specifying requirements and coordination, and their relationship with federal emergency water plans or requirements;

3. Any reports of actual situations which required the implementation of emergency water plans.

I am requesting identical information from all State Water Resource Institutes and will summarize the results in this study. I would appreciate receiving your reply by June 10, 1986. May I also ask you to indicate a point of contact in the event there is need to call for clarification. Thank you for your courtesy and assistance.

Sincerely,

John F. Langowski, Jr.
Research Associate

JFL/kb

Planning
& Management Consultants, Ltd.

808 West Main Street • P.O. Box 927 • Carbondale, IL 62901
(618) 549-2832

LETTER TO STATE WATER RESOURCES INSTITUTES

June 30, 1986

Dear :

On May 23, 1986, letters were sent to all State Water Resource Institutes to gather information concerning each state's emergency water supply planning activities. For your convenience, a copy of the previous letter is attached.

An evaluation of information from each state is essential to the development of a comprehensive bibliographical document. Your assistance in obtaining information regarding your state's efforts in the area of emergency water supply planning and provision will be greatly appreciated.

In preparing the analytical bibliography, the primary emphasis will be upon acute water supply emergencies resulting from natural or technological disasters, although some aspects of drought contingency planning will be included.

Please inform me if you require additional information or further clarification of the materials requested. To ensure the consideration of materials from your state, please respond by July 11, 1986. Thank you for your assistance in this matter.

Sincerely,

John F. Langowski, Jr.
Research Associate

JFL:kb

attachment

Planning
& Management Consultants, Ltd.

808 West Main Street • P.O. Box 927 • Carbondale, IL 62901
(618) 549-2832

LETTER TO STATE EMERGENCY MANAGEMENT AGENCIES

July 7, 1986

Dear :

Our firm has contracted with the U.S. Army Corps of Engineer Institute for Water Resources to develop a comprehensive analytical bibliography on the topic of Water Supply Planning for Emergency Situations. In preparing the analytical bibliography, the primary emphasis will be upon acute water supply emergencies resulting from natural or technological disasters. In this regard, I am writing to request your assistance in obtaining essential information. Specifically, I would greatly appreciate your providing us with:

1. A copy of state laws or regulations that contain emergency water planning or allocation provisions;

2. Copies of any emergency operations plans pertaining to water supply;

3. Copies of any reports of actual situations which required the implementation of emergency water plans.

I am requesting identical information from all state emergency management offices and will summarize the results in this study. To ensure the consideration of materials from your state, please respond by July 24, 1986. Thank you for your assistance in this matter.

Sincerely,

John F. Langowski, Jr.
Research Associate

JFL/bdp

III. A CRITICAL REVIEW OF EMERGENCY DISASTER ASSESSMENT SYSTEMS

III. A CRITICAL REVIEW OF EMERGENCY DISASTER ASSESSMENT SYSTEMS

INTRODUCTION

The purposes of this section are to (1) prepare an inventory of emergency disaster assessment systems which have been, or could be, applied to municipal water supply; (2) evaluate the systems; (3) identify the hazards to which they have been applied; (4) determine whether they include economic and social damage; and (5) discuss the extent to which they have been tested. Disaster assessment is considered here as it relates to damage to water supply systems and the subsequent economic and social disruption which might result. Hence, only a brief review of damage assessment models applied to residential, commercial, and public capital (roads, schools, and infrastructure) is provided.

It is significant to note, however, that the destruction of residences and commercial structures would play an essential role in shaping water demand, thus affecting the importance of restoring the system to its predisaster condition. The value of forecasting the extent to which water supply systems are vulnerable to both natural and man-made disasters hinges on the options available to decision makers. So too, the timeliness and accuracy of damage assessments are critical only in instances where an inadequate supply of water constrains the process of restoration and recovery. It is difficult, however, to sort out the influence of water availability from the wide variety of other forces which foster a return to normalcy. One cannot attribute all economic dislocations to water, nor would it be fair to conclude that water is irrelevant. From an economist's perspective, federal assistance is warranted in instances where the demand for water outpaces the ability of the local utility to supply it. The so-called shadow price of water, i.e., what consumers and producers would be willing to pay if an organized market existed, is a reasonable guide for determining the extent to which aid can be justified. In an indirect sense, the value of a disaster assessment system lies not only in the forecast of damage to the water system itself but, more importantly, in the determination of whether the surviving capacity meets postdisaster short- and longer-term demands.

The following section summarizes the results of the review of literature and the discussions with key experts in the disaster assessment area. The relevant information is organized into three major sections: (1) general social and economic considerations and approaches to hazard analysis; (2) assessment of earthquake losses; and (3) the consequences of nuclear war and critical elements of postattack recovery. Each section discusses major findings of several pertinent publications. The essential findings and conclusions of this evaluation are summarized at the end of this chapter.

INVENTORY AND EVALUATION

Guidelines for Conducting the Review

Our scope of work imposed no restrictions on the investigation in terms of disaster type. It turns out, however, that the greatest amount of work has been done on earthquakes and nuclear attack. The former is reviewed with the intent of summarizing the state of knowledge. The latter is discussed for quite different reasons. The nuclear disaster serves to illustrate the difficulties and dangers inherent in conceptualizing the impacts of high intensity events with low probabilities of occurrence. A brief discussion critical of previous scenarios is provided to illustrate.

Emergency disaster assessment systems were evaluated in terms of their applicability to water system emergency planning, their consideration of physical, economic, and social damages, and their level of reliability.

General Considerations and Approaches

Hazard Analysis

The Federal Emergency Management Agency (1983a) developed a document containing a general approach to hazards analysis, definitions, processes, and models. The purpose of the guide is to provide federal, state, and local officials with a common framework for hazards analysis.

The proposed method is designed to promote consistency of analysis by defining criteria and establishing a rating and scoring system. The rating and scoring system is based on the use of four criteria: history, vulnerability, maximum threat, and probability. The history is the record of occurrences of previous disasters. History must, however, be used with caution; the absence of a previously recorded specific event in an area does not necessarily mean that there is no threat. Vulnerability includes all persons who might be killed, injured, or contaminated, and all property that might be destroyed, damaged, or contaminated, and is measured by the number of people and the value of property in jeopardy. Critical facilities and special population groups can be identified in vulnerability descriptions. The impact of potential hazards not physically located in the community should be incorporated as well. The determination of maximum threat involves the assumption of the greatest event possible and of the greatest impact, or the "worst-case scenario." Maximum threat impacts are expressed in terms of human casualties and property loss.

Longer-term consequences are developed through more in-depth detailing of the event and impact possibilities and by utilizing existing statistical analyses. Secondary consequences should be estimated, if possible. Probability, or the likelihood of an event, can be expressed as the number of chances per year that an event of a specific intensity (or one greater) will occur. Probability is related to the history criterion; however, their separate consideration yields more meaningful results for the spectrum of events, from established hazard phenomena to newly developing hazards, than would a combined application.

Once the criteria have been identified, a simple descriptive rating system is applied to each. The ratings terms are: low, medium, or high. For historical ratings, low = 0-1 occurrences per 100 years; medium = 2-3 per 100 years; and high = 4 or more per 100 years. For vulnerability ratings, low = less than 1 percent of the populations at risk are adversely affected; medium = 1 percent to 10 percent are adversely affected; and high = more than 10 percent are adversely affected. For maximum threat ratings, low = less than 5 percent of the area/population impacted is at or near devastation; medium = 5 percent to 25 percent is at or near devastation; and high = more than 25 percent at or near devastation. Probability ratings are expressed in chances per year of a disaster; low = less than 1 in 1,000; medium = between 1 in 1,000 and 1 in 10; high = greater than 1 in 10. After rating the four criteria, numerical values are assigned depending on the rating issued. The ratings and their respective numerical values are: low = 1 point; medium = 5 points; high = 10 points. Some criteria are judged to be more important than others, so that a weighting factor is applied to balance the scoring. The criteria and their respective weights are: history = 2 units; vulnerability = 5 units; maximum threat = 10 units; and probability = 7 units.

The composite score for each hazard is obtained by multiplying the score value assigned to each criterion by its weighting factor and then summing the four criteria totals. A threshold can be used to refine the ranked list of hazards. A threshold score can be established which permits those hazards that have great frequency and the potential for major damage to a community to "pass through." These hazards can be given a higher priority for disaster preparedness planning. FEMA proposes a threshold score of 100 points, suggesting that any hazard having a total weighted score of 100 points or greater should be given the highest priority in disaster preparedness efforts. Hazards scoring below the threshold could be prioritized accordingly or, if clearly overshadowed by the major threat, ignored entirely in emergency management considerations. Although a single individual can conduct the hazard analysis, a team approach that uses the judgments of several individuals will be more thorough and increase the confidence levels of the completed analysis.

The document states that the applications of hazards analysis for water utility management should include the ability to (1) enable managers to establish hazard preparedness priorities and goals commensurate with the degree of need for protection; (2) provide descriptive information on every major hazard affecting a given area and a methodology for comparison of both similar and vastly different types of hazards; (3) justify management decisions for altering program and staffing assignments that may vary from previous norms in order to adjust to preparedness requirements; (4) substantiate decisions about resource allocations and justify budget requests through the possession of a quantified illustration of hazard; (5) encourage the identification of technological and research needs in the area of water emergency management; (6) provide tools to raise the level of understanding of public officials and to influence the adoption of prevention/mitigation measures and the expenditure of necessary resources; (7) enable the establishment of a viable national data base of hazard vulnerability and related information; (8) serve as the foundation for future utility emergency management activities; and (9) be sufficiently flexible to accommodate systems that have already performed hazards analysis.

This checklist approach to emergency management is vague and highly subjective. It is unclear how the information collected through the application of this system would assist either federal agencies in planning aid or public works departments in planning mitigation and response activities.

Social and Economic Implications

Cochrane, Ferrell-Dillard, and Baumann (1986) set down a theoretical framework for differentiating primary losses from secondary losses associated with disasters. The controversy over what to count as a loss in a damage assessment system revolves around two issues. First, it is argued that the summation of capital losses and regional employment effects involves double counting. Since the value of capital is the discounted stream of income generated as the result of employing that capital, its destruction is tantamount to the destruction of the income stream.

A second reason posited for questioning the inclusion of employment effects in loss estimates in a damage assessment system is the claim that whatever one region loses another may gain. Hence, from the standpoint of national economic efficiency, such secondary losses might well be ignored. The report points out that this contention is predicated on the assumption that excess capacity exists elsewhere and that the disaster-stricken region produces a generic product which could be manufactured elsewhere. It is suggested that in some instances these assumptions may be correct and in others they are not. Silicon Valley, for example, produces specialized equipment which may not be easily replicated. Bank computers located in downtown Los Angeles monitor transactions and process data for the entire western region of the country. The question is raised whether such services could be smoothly shifted to another banking center in the event of a catastrophic loss of computer facilities.

A historical review of regional damage assessment systems (employment effects) is reviewed. It is pointed out that early attempts to model the secondary effects of a disruption to a region's economy utilized Leontief transactions matrices as a basis for the creation of a linear program to maximize regional value added, subject to the postdisaster stock of capital. The shortcomings of such an approach are discussed. Particular attention is given to the question "is value added an appropriate indicator of the disaster victim's well-being?"

A hypothetical, and highly simplified, General Equilibrium Model of a regional economy is presented and discussed in order to delineate the issues. The authors believe that the sum of both direct and indirect losses stemming from a disaster can be determined by computing the compensation that must be paid the victims in order to restore the region's predisaster level of welfare. The effect of a hypothetical disaster was simulated, producing the following results.

> The compensation required to restore welfare can be less than, greater than, or equal to the value of the capital destroyed. It may take more than one time period for normalcy to return, in which case the cost of the disaster is the discounted stream of required compensation.
>
> If capital is perfectly mobile, disaster losses are identical to the value of capital destroyed. Damaged plant and equipment are instantaneously replaced at a cost equivalent to that prevailing prior to the disaster.
>
> If capital is not very mobile and imports are highly competitive (prices are equivalent) with regionally produced commodities, the damaged industry and other industries tied to it will never reopen. The losses in this case are the sum of direct damages, the cost of idle capital, and unemployed labor. In this instance compensation payments would be used to purchase lower-priced imports. As a result, the region's surviving capital stock would not earn rents (due to its scarcity) and there would be no reason to expand investment. The markets would be permanently lost.
>
> If capital is immobile, imports are more expensive then regionally produced goods and labor is easily substituted for the damaged capital, the discounted stream of <u>compensation is less than the value of capital destroyed</u>. This results from the combined effects of spending multipliers and the induced investment accelerator.

Based on these results the paper purports to have resolved the question, "Why haven't empirical studies of disasters detected significant economic dislocations?" The answer according to this report lies in the magnitude of the event, which must be highly destructive, disrupting the economy's primary industrial base. The report goes on to ask and then answer two ancillary questions.

Are disaster-induced employment effects, the so-called secondary losses, simply another measure of damage to productive capital? This is a special case which may be observed in a great number of "disasters," especially if the ratio of destruction to the resource base of the economy is low. In such instances it is safe to assume that damaged capital can be quickly replaced without creating costly production bottlenecks. However, the potential exists for employment effects to be quite large, particularly when a strategic industry is severely impacted.

Why have empirical studies failed to detect these secondary effects? A number of studies have focused on the longer-term prospects for recovery, which is somewhat different than income losses stemming from the disaster. Secondary effects are only observed for events which destroy a sizable percentage of the region's industrial base. Few, if any, of the disasters included in the statistical analyses reviewed were of this magnitude, hence, the conclusion that "disasters do not impact long-term economic growth."

Wright, Rossi, Wright, and Weber-Burdin (1979) focused on the long-range effects of natural disasters. Their research addressed the question, Does occurrence of a disaster alter the path of a community's economic growth, i.e., might the damages cause secondary effects which are detectable in secondary census data, specifically housing starts? Data were collected on approximately 10,000 events which occurred over the decade of 1960-1970. Simple regression analyses were performed to determine whether the so-called disaster-stricken communities suffered any lingering effects when compared with a randomly selected control group. The statistical analyses proved conclusively that no long-term impacts resulted.

The average tornado included in the Wright et al. study destroyed a mere three homes, hardly enough to tax even a small community, let alone a major metropolitan region. There are several other reasons for discounting the importance of these findings. Their conclusions are based on expected values, which are hardly an appropriate measure for a risk assessment. Second, it is a mistake to equate eventual recovery with the absence of secondary effects. The secondary losses are summed from the point when the disaster occurred to the time when recovery has been achieved. Last, Wright et al. argue that the provision of disaster assistance dampens the disaster's effects, thereby speeding recovery. However, isn't disaster aid a form of compensation, which in turn could include some of the secondary effects Wright et al. were trying to measure? The aid itself could be a measure of secondary losses.

This highly provocative study tended to be misread. It was relatively easy to wrongly conclude that the results showed no secondary impacts. Wright et al. were careful to point out that even though "We find no discernible effects of either floods, tornadoes, or hurricanes on changes in population or housing stocks experienced by counties in the period between 1960 and 1970" (p. 24), there are several reasons for this finding. "First, the damages and injuries directly attributable to the disasters are very small in relation to the population bases and housing stocks of the counties involved. Second, disaster policies on the federal, state, and local levels in effect during the decade of the 1960's have been sufficient to provide enough additional support for reconstruction to dampen considerably the lasting effects of natural disaster events on counties."

Assessment of Earthquake Losses

Systems or methods for asessing damages caused by earthquakes seem to receive the greatest attention in the disaster planning literature. We found several relevant literature references.

Friedman and Roy (1969) and Algermissen, Rinehard, and Dewey (1969) produced the earliest damage models. For the most part, their approaches are similar; they each begin with an idealized isoseismal pattern representing the areal extent of different earthquake intensities. The units of intensity are usually measured in the Modified Mercalli scale, which describes, qualitatively, the observed effects of the earthquake (e.g., toppled chimneys, etc.). Although not a scientific measure of ground movement, the Modified Mercalli scale is still used, primarily due to the fact that historical events can be described with such an index.

The typical event simulator is usually described as one in which the isoseismal patterns conform to certain regularities. Large earthquakes produce roughly elliptical damage contours, while smaller earthquakes are approximately circular. This seemingly regular behavior of earthquake damage patterns is explained by the fact that large earthquakes are normally a product of extended slippage along a major fault. It has been observed that, in fact, fault movement and earthquake magnitude are related. A large earthquake on the order of Richter 8.5 produces a movement of nearly 500 miles, while a smaller shock (Richter 6.5) creates faulting which seldom exceeds ten miles. Although the idealized isoseismals approach an elliptical shape, the actual contours are shown to be somewhat irregular. Friedman and Roy (1969) explain that the irregularities are due to variation in local geologic conditions. The reported difference between the intensity on relatively soft alluvium and that on hard granite is almost 2.5 intensity units (Modified Mercalli), enough to considerably alter the type of damage experienced in a location.

The assessment of earthquake hazards and the vulnerabilities of water systems in the U.S. has been focused primarily on the San Francisco Bay area. The following section presents major considerations in emergency planning by water utilities located in that area.

Expected Losses in the San Francisco Bay Area

Algermissen, Reinhart, and Dewey (1972) described a damage assessment system which focuses on emergency water management. The report first provides useful background information regarding the San Francisco and East Bay water utilities. The San Francisco Bay Area draws its domestic freshwater supply from several sources within and outside the study area. Local resources serve mostly the North Bay Area, while the other areas generally rely on supplies imported from elsewhere. The two largest water supply agencies are the San Francisco Water Department and the East Bay Municipal Utility District (EBMUD). Approximately four/fifths of the San Francisco Water Department supply comes from the Tuolumne River watershed in Yosemite National Park; this is part of the Hetch-Hetchy aqueduct system.

Two Hetch-Hetchy water supply aqueducts (constructed in 1925 and 1935, 60-inch and 66-inch diameter lines) are protected by pairs of expansion joints where they cross the Hayward Fault in the city of Fremont. In recent years, the East Bay Municipal Utility District has placed additional storage reservoirs on both sides of the Hayward Fault with at least a partial view toward minimizing the effects of pipe breakage as a result of earthquake effects. Many other examples of similar advanced planning can be cited. However, out of necessity some facilities had to be located on/in landslide regions and on liquefiable sands placed over San Francisco Bay muds.

The discussion of earthquakes on the San Andreas Fault is limited to the Hetch-Hetchy water system which supplies San Francisco and a number of municipal utilities in San Mateo, Santa Clara, and Alameda counties. Water is obtained from the Sierra Nevada and from the Santa Cruz Mountains. The principal local storage is the San Andreas reservoir and the Crystal Springs reservoir, both located on the San Francisco Peninsula. Water from these two reservoirs, both on the San Andreas Fault, is transmitted to San Francisco through five aqueducts to moderate-size reservoirs and water tanks in that city.

The report concludes that the Hetch-Hetchy aqueducts can be expected to deliver water to the Peninsula reservoirs, and these reservoirs can be expected to remain intact. Damage is likely to be repaired quickly where one conduit enters an underwater crossing of San Francisco Bay. However, half of the aqueduct supply from the San Andreas and Crystal Springs reservoirs should be assumed to be out of service for a week; but, as in 1906, the storage reservoirs located in San Francisco will function. The authors believe that performance of the San Francisco water system in an 8.3 magnitude shock will surpass that observed in 1906.

The report estimates that distribution system damage and water outages within San Francisco will be heavily accentuated in the structurally poor ground areas which border the Bay. Elsewhere, the water distribution system is expected to remain mostly intact, and significant outages will be few and controllable, commensurate with availability of spare pipe, fittings, and accessability. For scenario purposes, 90 percent of the water outages in these poor ground areas should be restored within three weeks by above-ground piping similar to that which was used in San Fernando.

It is evident that any significant length of movement on the Hayward Fault will disrupt many of the East Bay Municipal District's (EBMUD) aqueducts. The authors believe that all aqueducts will fail or be badly ruptured as a result of magnitude 8.3 and 7.0 shocks. Some may still be able to transmit small amounts of water. However, the water supplied by conduits will be assumed to be reduced to 5 percent for 24 hours, then to 20 percent of capacity after 24 hours. In the event of a magnitude 6.0 shock, all lines will be assumed to function at 80 percent of capacity.

The situation for most of the area served by EBMUD is thought to be more critical than that for San Francisco. This is because the Hayward faulting could isolate the main EBMUD storage areas from its main distribution system. In addition to the loss of water supply due to ruptured aqueducts, many distribution lines cross the fault, and these will also be ruptured.

By comparison, San Francisco and the Peninsula communities are fortunate with respect to a major Hayward Fault earthquake, since these cities will have large water supplies available in the San Andreas and Crystal Springs reservoirs, and this storage represents an adequate supply until the fault-ruptured aqueducts are repaired. However, no cross-connection exists to allow the use of this water by EBMUD. Accentuated damage to the distribution system will occur in the structurally poor ground areas of the East Bay, but only nuisance damage in similar poor ground areas across the bay is expected.

Because of the geological and geographic conditions beyond the control of the water utilities serving the East Bay cities, the water supply systems are expected to be severely crippled in a great earthquake and full permanent restoration of service could reasonably take half a year. The foregoing includes the possibility of storage dam failure.

Despite the fact that the report is somewhat dated, it still serves as a model for conducting a damage assessment. Based on discussions with EBMUD planners conducted in August, 1986, the process described in this report is still being refined by San Francisco area water utilities. Risk-cost assessments based on a similar methodology have been responsible for enhancing the security of the EBMUD supply, purification, and distribution systems. It appears that even though few damage assessments of this quality are published, some California facilities produce internal working documents of equal or superior value.

Economic Effects of Earthquake Damages

Typically the availability of information and/or experience with major earthquakes determines the selection of study areas for the analysis of economic implications of such a disaster. The San Francisco Bay area and Japan are two areas where research inquiry is focused. Cochrane, Haas, and Kates (1974) proposed a way of estimating the indirect losses from disasters. The technique is demonstrated using a simulated recurrence of the 1906 San Francisco earthquake in 1974. It is argued that direct damage of productive capacity would retard the production of intermediate goods in the region. To the extent that serious shortages of critical goods develop, and inventory levels are insufficient to absorb the effects of supply disruption before alternate supplies can be found, a further decline in regional output would be expected. It is this complex interaction of supply, demand, and damage which forms the basis of the analysis.

Direct damages were estimated by overlaying previously published isoseismal patterns on a map of planning districts showing the relative concentrations of residences, the number of persons employed in basic industry, and the number employed in local service industry.

The resultant disturbance to the region's productive capacity was analyzed to determine how these effects filtered through other industries. Unemployment produced by supply constraints was translated into reduced demand for goods and services still produced in the region. The paper proposes that property and sales tax revenues would decline at a point in time when the need for expenditure is the greatest--when reconstruction of public facilities, roads, and utilities is vital to the recovery of the economic structure.

Several simplifying assumptions with regard to prices and production technology were employed, permitting the problem to be formulated within a linear programming framework. Regional product was maximized subject to the constraints imposed by the surviving resources and the preearthquake technical coefficients of production.

The paper points out the importance of focusing on value added rather than gross regional product in interpreting the results. The former is shown to decline by $14 billion, while the latter is reduced by $6 billion. Regional product includes not only the value of economic activity of the region but also the value of goods and intermediate products made elsewhere. Value added reflects income to labor, capital, and other factors of production received within the region. It is therefore a more accurate reflection of the disruption an earthquake of magnitude 8.3 could produce.

In summary, the authors conclude, "A repetition of the 1906 San Francisco earthquake would cost the Bay area a minimum of $13 billion, but the employment of more pessimistic assumptions than those used in this study may escalate the cost by a factor of three or four. These losses would be divided almost evenly between direct damage to personal, business, and public property (primary impact), and indirect damages in the form of a decline in regional economic activity (secondary impact)."

This study is one of the earliest attempts to derive an estimate of employment effects caused by natural disasters. Because of this, the tools are crude and the results are primarily illustrative. A number of subsequent studies have been performed, some of which are included in the review. The primary criticism which can be leveled at the linear programming approach, which the study employs, is that the technical coefficients are unlikely to remain fixed during the period of reconstruction. In addition, rigidities in the economic system may preclude the rapid reallocation of resources portrayed in such a model.

A similar study of earthquake losses in Japan was conducted by Kuribayashi, Ueda, and Tazaki (1985) who performed a mutiple regression analysis of the past six earthquakes to strike Japan during the period 1964 to 1978 (M 6.4 to M 7.9). A time-series analysis of direct losses (number of victims and capital losses) provides a set of equations to describe indirect losses (employment effects). The equations developed for the purpose of estimating the cost of repairing lifelines and the restoration period are also provided. A simulated recurrence of a Richter Magnitude 8+ earthquake in Shizuoaka was estimated to produce loss ratios in the range of 4 to 5 percent. The longer-term economic consequences of such an event were reported to result in a 6.3 percent reduction in regional product.

The authors caution that the indirect loss model's results should be viewed with some skepticism, since the parameters of the regression equation were assumed to remain unchanged as a result of the earthquake. They recommend that additional research be conducted to determine the extent to which the underlying economic structure may be altered as a result of a catastrophic event.

An equation was developed which relates water supply outages to the number of households affected and earthquake acceleration. The restoration period is purported to be a function of the damage ratio. It is surprising to note their claim that for damages as great as a 65 percent loss, service could be restored within a month.

The report provides one of the few empirically based projections of direct and indirect earthquake losses. This is due in part to the fact that earthquakes occur more frequently in Japan than in the U.S. thereby providing more data on which to build statistical models. The model on which indirect losses are founded could be improved through the application of a tighter conceptual framework. In addition, it is not clear from the paper how damage to the region's water distribution, purification and storage facilities contributed to the economic impacts noted.

Earthquake Risk and Damage Functions

The assessment of the potential impacts of seismic hazards in other areas is often based on simulations models which use probabilistic approaches to earthquake risk analysis. The following section discusses four studies which treat the earthquake risk and damage functions using such an approach. Midwest Research Institute (1979) published a study on the social and economic consequences of possibly damaging earthquakes in the New Madrid Seismic Zone. The objectives include the development of a simulation model so that various physical damage functions can be empirically estimated, then converted into economic damage values. A third essential component of the study is an examination of the institutional aspects related to government and community preparedness and response.

Both probabilistic and deterministic approaches were utilized in the earthquake risk analysis. In determinining the physical damage functions for different types of earthquake risk receptors (populations at risk), especially for structural damages, the surface materials and ground conditions were studied. The 15-county study region was reclassified into six major categories of vulnerability. The vulnerability indexes developed were utilized as the weight factor in the physical damage function. Three categories of populations subject to earthquake risk were identified: (1) human populations (diurnal and nocturnal), (2) structures, and (3) personal property. The basic data unit was a census tract, and the aggregate level of estimation of population at risk was a county. For structural populations both the market value as assessed by county assessors and the replacement cost of new construction estimated by a structural engineer were employed to illustrate range variation. In the development of physical damage functions, econometric techniques of linear and log-linear regressions were employed to estimate the functional relationship between physical earthquake damages, the damage ratios, and the Modified Mercalli intensity of various earthquakes occurring in the United States. This was done in conjunction with exogenous determinants such as population density, distribution of the structures, the type of construction material, and age of the structures. A recursive model of structural damage, property damage, and human mortality and injury was constructed to illustrate the interdependent relationships among these risk receptors. Baseline data and the projected values of populations were fitted to the model to simulate quantitatively the potential damage of various earthquake risks that the study region will face from 1980 to 2030 with virtually no additional hazard mitigation action or risk reduction program implementation.

A thorough discussion of results for the New Madrid Zone is offered but not summarized herein. The researchers note that the damage results estimated in their study are much smaller than those of other investigations; conservative estimates are useful as baseline information, and the reduction of damage estimates may reflect increasing seismic awareness and adaptation. Recommendations are made that the physical damage functions be further refined and disaggregated, and that additional research be directed toward finer risk population estimation.

Bresko, Hendrickson, and Oppenheim (1981) devised an assessment system aimed at estimating the cost of repairs of the water network damaged by an earthquake plus the economic disbenefits resulting from a lack of water service (user loss). Losses in a single earthquake are estimated in four steps:

(1) The probability of failure of each component of a water network is predicted as a function of ground motion at that site:

$$\begin{aligned} \text{Log } N &= 3.65 + 6.39(-2.98 + 0.30\, I) \text{ for } 7 < I < 8 \\ N &= 2.0 \text{ for } I = 9 \\ N &= 32.0 \text{ for } I \geq 10 \end{aligned}$$

where: N = the number of pipe breaks per kilometer of pipe; I = earthquake intensity.

For a pipe of length L, the probability of pipe failure is calculated using a Poisson distribution:

$$\begin{aligned} P(\text{pipe fails}) &= 1 - e^{-NL} \\ P(\text{pipe does not fail}) &= e^{-NL} \end{aligned}$$

The damage for water treatment plants and pump stations is calculated as:

$$\begin{aligned} C/Co &= 1.0 - 10^{(-8.54 + 0.95I)} \text{ for } 7 \leq I \leq 9 \\ C/Co &= 1.0 - 1/3\ (I - 7.0) \text{ for } 7 < I < 10; \text{ and} \\ P(\text{component fails}) &= 1.0 - C/Co \end{aligned}$$

where: Co = undamaged capacity and C = expected post-earthquake capacity. The expected value of repair costs are calculated based on these probabilities of failure.

(2) The reduced network flows are calculated through a network analysis with link capacities represented in probabilistic terms.

(3) The reduction in network flows is converted into an economic measure of user loss. The total loss is defined as the sum of repair cost and user losses; the latter was set at \$0.04/gallon for residential use and \$0.16/gallon for industrial use in an illustrative application of the model for Salt Lake City.

(4) A repair process is simulated to determine total user losses over time.

The authors determined that for a hypothetical example based on the Salt Lake City water system, the probability of incurring some cost in any year is 0.00872 corresponding to an average return period of 115 years. Using the mean loss of $296,643 and a population of 334,000, the per capita loss is $0.88 on an annual basis.

Roberts, Milliman, and Ellson (1982) summarized advances in methodology to estimate the regional economic impacts of earthquakes and earthquake predictions. A regional economic model is proposed which accounts for (1) supply-side constraints; (2) the potential use of new and currently unused technologies; and (3) the decisions by firms and households to relocate in response to an event or a prediction. The regional econometric model is used to establish a base line against which the effects of an earthquake could be measured. Three simulations were conducted to determine the impact of an unanticipated disaster. The simulation results, in the form of aggregate regional effects on population, employment, and personal income, show that the regional economy is resilient and that recovery is assured even in the event that pessimistic assumptions are employed. According to the authors the key to recovery lies in national growth factors which drive regional economic conditions. Losses are shown for the region as a whole and also for each of the three counties. Capital losses prove to dominate regional income effects. The rationale offered for this finding is that recovery from the event, i.e., investment in new buildings and equipment causes a multiplier effect which tends to mask the effects of the disaster.

The report underscores several findings important from the standpoint of the emergency water problem. The regional losses may be different from national losses due to the fact that production gains in other regions can offset or substitute for production losses in the region hit by the disaster. The authors go on to argue that if regional production is not capable of being substituted for by production in other regions, then national production may not make up for regional losses. It may even turn out that production elsewhere drops due to the lower availability of an "essential" product. Therefore, they strongly recommend against tying a regional input-output model to a national input-output model. To do so would imply that the coefficients are fixed and that no substitutions are possible; this may prove to be incorrect.

The report represents an important contribution to the literature in that it changed the way in which economists looked at secondary losses. It questioned the use of fixed interindustry coefficients to model disaster shocks; it identified the potential for double counting losses (both damage to industrial capital plus the income which that capital yielded its owners); and it provided a foundation for discussing the difference between regional and national losses. On the negative side, it promised to employ a "process model" approach to predicting how industries would respond to supply shocks. It appears that the strategy proved to be more time-consuming and challenging than the authors originally thought. The partial success they report could be interpreted to mean that the approach is theoretically superior but not as practical from the standpoint of data requirements and difficult in terms of its implementation.

Salkin and Lindsey (1986) reviewed the results of FEMA's Earthquake/85 Exercise as it pertained to the impacts of water systems. The exercise was conducted to determine the effectiveness of regional and national plans in coping with a disaster of major proportions.

A regional economic analysis was performed using an input-output data base (IMPLAN) for five California counties. The scenario which formed the basis for making projections regarding the economic impact was as follows:

> . . .The catastrophic earthquake was simulated to have occurred at 09 30 P.D.T. June 17, 1985, in the Southern San Andreas Fault region between Gorman and Palmdale north of Los Angeles, causing a surface fracture nearly 150 miles long. . . .The earthquake measured 8.3 on the Richter scale and lasted for 45 seconds. Initial casualty estimates were 5,000 killed. . . .The catastrophic earthquake and aftershocks caused severe damage to medical, transportation, energy, water, communications, and sanitation systems..." (p. 2).

The authors utilize the estimated direct damages along with the interindustry coefficients provided by IMPLAN to develop a linear programming model which maximizes value added subject to the postdisaster damages (production constraints). A numerical example, based on the FEMA exercise, illustrates the impact of an 80 percent reduction in water availability. The model shows that nearly $55.6 billion in outside assistance would be required to provide surviving households a satisfactory level of material comfort.

The application of a linear programming model to the problem of postdisaster reconstruction is questionable. It is not clear that the economy will behave as efficiently as might be suggested by this approach. Capital, resources, and production may not move according to the shadow prices implied by the optimal solutions. On the other hand, fixed production coefficients may be overly constraining. Input-output statistics, upon which the linear program is based, reflect the long-run steady state tendencies of the economy; in all likelihood the intra- and intertrade flows would adjust during the recovery period, a factor which a programming solution such as this cannot reflect. Most important, the estimates of economic loss presented in the paper are, as the authors admit, hypothetical.

Effects of Nuclear Attack

The second most frequently studied type of hazard is nuclear attack. This section summarizes several studies which discuss the

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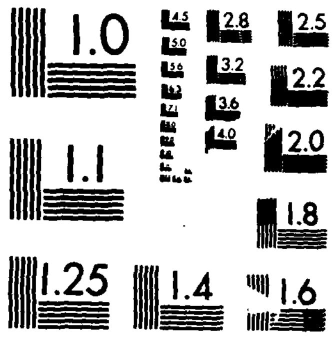

MICROCOPY RESOLUTION TEST CHART
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consequences of nuclear war and the most critical issues of postattack recovery.

The Consequences of Nuclear War

Cochrane and Mileti (1986) investigated the consequences of nuclear war from the social and economic points of view. The authors argue that many of the assumptions regarding evacuation, the resilience of the economic infrastructure, and the nature of the postholocaust social and technical system have not been seriously questioned. As a result, the authors suggest that many of the projections which are based on extrapolations from the current set of social arrangements are misleading at best. The following are key concepts: (1) short-term medical consequences, (2) long-term health effects, (3) prospects for a general economic recovery, and (4) the difference between the potential U.S. experience and that of Germany and Japan.

The report begins by briefly reviewing the literature regarding the direct medical consequences of a sudden nuclear attack which leaves the targeted population no time to seek shelter. The calculations presented are sobering. Of the 93 million survivors, 32 million would require medical care. If health care assistance is based on preattack medical procedures, the estimated 48,000 physicians surviving the attack would face a workload which would tax the capabilities of 1.3 million physicians (Abrams, 1984, p. 657).

It is postulated that maintenance of a reasonable standard of health may be impossible without the rapid recovery of the economy's critical industries: petroleum, petrochemicals, electronics, agriculture, and pharmaceuticals. Without these, it is suggested that the transmission of disease may go unchecked, and, as a result, the greatest risks to health are argued to lie in the postattack period. The prolonged period of crowding in makeshift fallout shelters, which are likely to be poorly ventilated and ill equipped to treat or dispose of wastes, would create the conditions for a rapid spread of disease. Provided that the survivors endure this period, they would face similar difficulties outside. The lack of sanitary systems, the absence of power for refrigeration, the presence of millions of unburied dead, and a disturbed ecological balance fostering a rapid growth in insect populations would combine to produce an environment conducive to the contraction and transmission of disease. The complex interactive effects of stress, malnutrition, and an immune system damaged by radiation would tend to weaken physiological defenses to a point where people may succumb to diseases presently considered to be only moderately virulent (Leaning, 1983, p. 424).

The economic infrastructure left intact after the attack would play a key role in determining the length of time during which such life-threatening conditions might persist. The survivors would face the critical task of rebuilding a viable economy capable of rapidly reallocating undamaged capital and distributing uncontaminated foodstuffs. The few studies which have dealt with the issue of economic recovery are reviewed. Potential Vulnerability Affecting National Survival (PVANS), a study prepared in 1970 for the Office of Civil Defense by the Stanford Research Institute (SRI) (Goen et al., 1970), estimated the fewest number of nuclear detonations required to "prevent economic recovery." The attack which SRI found to be most effective in achieving this end combined the destruction of the industrial capacity located in 71 of the nation's largest standard metropolitan statistical areas with the simultaneous targeting of eight critical industrial sectors. The attack was assumed to reduce industrial output to less than 3 percent of the preattack level. The industries considered critical are (1) petroleum refining; (2) iron and steel works; (3) primary smelting and refining of zinc, copper, lead, and aluminum; (4) engines; (5) electrical distribution products; (6) drugs; (7) office machines; and (8) mechanical measuring devices. SRI concluded that a crippling blow could be delivered by a combination of 500 1-megaton and 200 to 300 additional 100 kiloton weapons. This number is only 10 percent of that posed by the formulators of the CRP-2B scenario, a base case adopted by a number of federal agencies.

The SRI results have been subjected to refinements by Katz (1982, p. 115) and others (Sassen and Willis, 1974). The updated studies suggest an even lower exchange threshold (100 to 300 megatons) would result in "unacceptable" economic disruptions and bottlenecks.

Several reasons are offered for doubting the projections. The tools available to researchers are based on historic patterns of production and institutional arrangements. However, these are likely to change during the period of reconstruction. In addition, the authors question whether sufficient reserves of domestic oil and gas exist to meet the needs of both reconstruction and production of essential consumer items. The reliability of traditional international trading patterns is also questioned as to whether such patterns might fail to return to their prewar state. The economic consequences of destroying highly sensitive data processing and retrieval facilities in terms of postwar reconstruction are addressed.

The question is raised as to whether nuclear war will bear any resemblance to the experiences of Japan and Germany. The postnuclear recovery periods estimated to last a decade or more are noted to contrast sharply with the recorded postwar economic performance of both Germany and Japan. Each sustained heavy losses but were able to reestablish viable economies within five years after cessation of hostilities. What forces led both of these nations to their current economic prominence? Could such factors produce a rapid economic recovery in the United States? The authors discuss the possibility that the factors which coalesced to create a favorable climate for both the Japanese and German economies are unlikely to recur. Fossil fuels during the postwar period were both plentiful and inexpensive. Contrary to popular belief, Germany sustained relatively minor damage to its productive capital. "It must be emphasized that bomb damage to industry, as opposed to transport and housing, was relatively negligible. Germany's . . . postwar industrial potential was roughly equivalent to that which had existed in 1938" (Owen-Smith, 1983, p. 13). Its index of industrial production dropped from a prewar high of 149 (in 1940) to 31 in 1946 (Allen, 1963). The previous high was not regained until 1953, although it grew steadily throughout the intervening period. The authors indicate that both Japan and Germany benefited greatly from external aid, primarily from the U.S. Assistance to Germany alone amounted to $3.6 billion between 1946 and 1953, a sizable amount, especially when measured in current dollars. Japan's economy benefited equally from the aid it received. The Korean War served to stimulate demand for its products at a point when U.S. aid was dwindling. That plus a postwar economic boom which fueled demand for vessels fabricated in Japanese shipyards all provided a sound platform for recovery. A plentiful supply of cheap energy throughout the fifties and sixties provided both countries the opportunity to maintain a sound longrun growth path.

Despite the short-term hardships both countries benefited greatly from a fortuitous combination of factors which are unlikely to be repeated. No nation would have the resources or possibly the will to come to the aid of a United States devastated by a nuclear exchange. Foodstuffs would be hoarded rather than shared. No worldwide economic boom would ensue. Without an external source of demand for its products, the U.S. economy would languish.

A similar study on the effects of nuclear war conducted by Haaland, Chester, and Wigner (1976) was focused on the survival of the relocated population of the U.S. Information was provided that was necessary for FEMA to evaluate nuclear Crisis Relocation alternatives. The report, therefore, concentrates primarily on issues such as transportation, availability of shelter, communications, and the radiological hazards the survivors would have to face. Only two of the report's nearly 200 pages are devoted to the problem of emergency water. The important excerpts are provided below.

> For most areas designated as reception areas in the U.S., there are abundant water sources. In many localities, local water purification equipment will be overloaded if evacuees and hosts attempt to use water at the precrisis rate of 100 gal/day per person. . . .In general there will be enough water such that people will not die of thirst in the postattack situation.
>
> There may be a problem in some locations with soluble radioactive components of fallout, such as iodine, which may require special treatment of water by filtration, or distillation, or which may be counteracted by prophylactic measures. Radioactive iodine will not be present in well-water, but may be prevalent in lakes in fallout-contaminated areas. If this water is to be used it should be filtered. Filtration through about 5 in. of soil will remove the iodine. . . .Extensive research on expedient methods to remove radioactive contaminants from water has been performed by the Corps of Engineers (p. 105).

Calculations indicate that the radiation dose due to consumption of water which contains other soluble nuclides, such as strontium and cesium, would be negligible for a 1,600 MT attack but could be harmful for larger attacks.

These conclusions are questionable. Whether the populations in high-risk areas relocate, as FEMA has planned, is debatable. Enough is known about social response to earthquake prediction and to other disaster warnings to cast significant doubt over the assumptions used in the research.

Another critical issue is the compositional changes that massive nuclear attack might produce in America's societal structure. Hanunian's (1966) estimations of overall survival magnitudes--in terms of the usual gross indicators--have been included. The most important findings tend to relate to attacks which are of a lesser magnitude. They are as follows:

Attack impacts are shown to vary significantly among regions. Even though the eight attacks analyzed can hardly exhaust the set of possibilities, it is projected that certain regions would tend to suffer relative to others. The southeast and the Pacific Northwest generally fare better than average, the northeast and especially California, worse. Further, at least where heavy attacks are concerned, whatever region fares worst typically experiences a survival rate less than half that of the region faring best--far more extreme possibilities are reported. Urban people tend to fare much worse than farm people. Not only is it usually urban people who fare badly, but in those instances where survival rates for the two groups are particularly disparate, it is always the urban people who fare the worst.

According to one tentative computation with this model, a (representative) heavy attack that killed 54 percent of all people would kill 47 percent of those 5 to 64 years old, 74 percent of all children under 5, and 87 percent of people 65 and over. In short, this calculation shows that people whose ages at the time of attack placed them very near either end of the normal life span would have extraordinarily poor chances of survival.

Another investigation revealed that nuclear attacks would tend to discriminate against high-income families. Families with 1959 incomes of $10,000 or more (such families account for one-third of all income generated) would survive at rates only 75 to 85 percent as high as those for the general population. Such a prospect is of interest because, among other reasons, it implies that attacks are apt to eliminate selectively those persons currently deemed most productive.

The study proceeds from the consideration of essentially demographic entities to economic ones, examining the full range of economic activities by reference to a disaggregation of the labor force and to certain other indicators. As before, it is only between urban and farm entities that large disparities are common. Nevertheless, it is shown that workers in wholesale and retail trade, in construction, and in education tend to fare somewhat better than average, while those in finance, insurance, real estate, and public administration tend to fare worse. (That the latter two categories fare relatively badly reflects their concentration in New York and in Washington, D.C., respectively, and a tendency for such cities to be attacked.) Among elements of the farm sector, it is the city-oriented activities--notably dairying and poultry raising--that tend to suffer.

Many of the conclusions reached in the report are not very surprising. However, few studies have focused on demographic issues. As a result, this report provides the basis for creative speculation regarding the nature and composition of the postwar social system.

Useful background information regarding the direct effects of nuclear detonation is provided in a World Health Organization (WHO, 1984) report. It contains a comprehensive review of the current state of knowledge regarding social and economic consequences of nuclear war. The following excerpts relate to emergency water supply: "In the havoc following the attack water would be a crucial issue, since main water supplies would probably be destroyed or damaged. Water was in great demand among survivors in Hiroshima and Nagasaki, as is strikingly shown in the recollections of the survivors. . . . Large quantities of water, up to 10-20 liters per day, would be required for burn cases. At least 4 liters per day of drinking water would be required to prevent dehydration in the survivors" (p. 93).

> Water supplies in the postwar period would be directly and indirectly affected by the thermonuclear explosions. A serious problem would be radioactive contamination of the fresh water systems by iodine-131, strontium-89, strontium-90, and ruthenium-106 in regions exposed to local fallout. Rainfall would concentrate the radioactive fallout in some localities, producing high levels of contamination. Stream water would be contaminated well above safe levels for drinking. This situation would persist for a period of about 4 weeks and be followed by much longer period, possibly lasting years, in which low level radioactivity, primarily from strontium-90 and cesium-137 would persist. Ground water would not be as contaminated as other fresh water reservoirs (p. 93).

> The danger of ionizing radiation from the contamination of fresh-water systems is relatively small in comparison with the hazards of radiation released by the initial explosion or the introduction of radioisotopes of strontium, iodine, and cesium into the food chain from the fallout deposited on the ground. The number of people killed or made severely ill by drinking contaminated fresh-water (other than rain) would nevertheless be substantial (p. 142).

The section on emergency water in the WHO report is both limited and dated. The longer-term effects of the catastrophe and subsequent social and economic consequences are given scant attention. The latter are addressed by Dresch and Ellis (1974), who developed formulas for assembling and analyzing lists of variables and factors that could affect viability or degrade potential output of SMSAs after a nuclear attack. Such formulas should assist in assessing the economic viability of an SMSA and in making decisions on abandoning a site temporarily.

Recovery Following Nuclear Attack

While the information on the potential impacts of nuclear war seems to be generally available in the open literature, the issues related to postattack recovery are considered less frequently. We identified only three studies which pertain to this area.

Brown (1971) developed a particular scenario involving an international crisis which over a period of several months escalates to a 4,000 MT nuclear attack on the U.S. Because of the long crisis period, a partial evacuation of the urban population occurs. The attack is assumed to incapacitate the federal government and most of the state governments, resulting in fragmentation of the nation into thousands of autonomous entities, each most concerned with its own problems. The major difficulties during the first few weeks occur in the parts of the country with the most intense radioactivity and/or the greatest shortage of food and fuel. The concept of rescue or assistance to neighboring communities fails because of the extreme threat to survival prospects felt nearly everywhere and because of the lack of a national authority with the capability to effect the required actions.

A dynamic computer simulation model, which represents the production, import, and distribution of key groups of natural resources has been developed (Pugh-Roberts Associates, 1981). The model is a tool for assessing the vulnerability of the U.S. economy to various degrees and types of damage to its natural resource sectors. The model can be used to analyze the impacts of resource availability and U.S. government natural resource policies on the process of postnuclear-attack economic recovery.

The model is characterized as a dynamic, input-output simulation of the natural resources portion of the U.S. economy. The natural resources portion of the economy is represented by four sectors: (1) metallic durable materials, (2) nonmetallic durable materials, (3) energy products, and (4) nonfuel consumable materials.

The results of the attack scenario and policy tests indicate that recovery following a nuclear attack requires the reestablishment and maintenance of a dynamic balance among the interdependent sectors of the economy. Under a wide range of attack scenarios, the natural resource sectors are shown to be sources of dangerous imbalances that could constrain recovery of the overall U.S. economy.

The systems approach used in this study provides useful insights into the degree to which the resources sector is integral to recovery. Some degree of skepticism has to be expressed regarding the applicability of systems dynamics models, such as that employed in this report, to an event as catastrophic as nuclear war. The relationships on which the simulation is built are based on historical observations. It is highly unlikely that the models could anticipate the extent to which fundamental relationships might change during the postwar period.

Finally, Bull and Adams (1975) reviewed the Runout Production Evaluation (ROPE) model for simulating regulated resource management in the first ninety days following a nuclear attack. The report does not, however, provide any results. The model does not deal with transportation constraints such as fallout barriers, destroyed bridges, or petroleum shortages; hence, the usefulness of the model as it is described in this document is doubtful.

THE ESSENTIAL FINDINGS

It is clear that the federal government cannot plan for all contingencies nor can it provide aid to all disaster stricken communities that experience difficulties in their ability to supply water. Nonetheless there appears to be a heightened concern that the economic and social fabric is growing increasingly vulnerable to both man-made and natural disasters. Unfortunately there is little evidence to either support or refute this contention. Based on our initial review of literature there does not appear to be any single Emergency Disaster Assessment System which has been promoted or adopted by utilities or agencies charged with disaster preparedness. Instead we have found checklist systems such as FEMA's Integrated Emergency Management System which ironically would be of dubious value in managing an emergency. In addition, the review revealed a set of *ad hoc* studies of how water systems have fared or could fare in the event of a large earthquake. We have found these to be quite valuable in formulating an image of the role water supplies could play in recovery.

After reviewing the literature it became evident that damage assessment is both an art and a science. However, in the process of digesting published research and talking with water district staff several observations crystallized. They are reported below.

1. Water utilities appear to be aware of their vulnerability; it seems that it is the uncertainties associated with proper risk-benefit assessment which prevents them from further reducing the chances of lengthy outages.

2. Utilities do perform damage assessments. In some cases the approach adopted incorporates a blend of seismology, soils and structural engineering, and economics. Utilities appear to believe that they can deal with outages without external assistance.

3. Several papers have been published relating distribution system damage to earthquakes. This is probably the simplest damage assessment system. The impact of outages on households and commercial activities has not been carefully analyzed or tested.

4. Damage assessment is typically comprised of two elements, direct loss incurred by the utility (distribution, storage, and purification facilities) and the impact of the outage on the service region. Direct losses seldom amount to more than 5 percent of aggregate damages. It is unlikely that significant or measurable secondary losses would be observed, providing the outage lasts less than five weeks and amounts to no more than a 40 percent reduction in volume delivered.

5. Disaster-induced employment effects are rarely detected. The statistical studies that have been performed have failed to demonstrate their existence. This is due in part to the events which are included in the sample; the average tornado, for example, destroys <u>three</u> structures, which would be undetectable by statistical methods.

6. A variety of simulation techniques have been employed to determine the effect of truly catastrophic events on regional and national economies. The requirement for such an approach is obvious in that experience with extraordinary earthquakes and nuclear war is limited. The credibility of simulation should be seriously questioned. In many instances the technicians employed assumptions based on predisaster economic and social conditions. In reviewing the literature it became painfully evident that logical and piecemeal approaches have gained favor over more imaginative strategies.

7. The published literature on the social and economic consequences of nuclear war has addressed all conceivable aspects, ranging from food distribution to the availability of fossil fuels. The impact on the nation's water supplies has only been given scant attention.

8. The literature is "rich" in methodology and poor in data.

9. The literature which explicitly addresses the emergency water question tends to focus on the utility in isolation. Damage assessments which stop at the utility fail to recognize that the primary damages are sustained by the customers. Little effort has been devoted to quantifying these losses.

10. The rationale which is offered to support federal involvement in crisis situations is that assistance will prevent sizable economic losses which would be sustained if aid is withheld. It is perceived that lifelines are an integral part of a "fragile" economic infrastructure, and any break in the provision of such services would induce severe economic repercussions. As logical as such a statement may appear, a great deal of confusion exists regarding just how large these secondary losses have been or could be. Matters are further complicated by the fact that researchers have tended to confuse direct and indirect losses, thereby introducing some measure of double counting. Despite the importance policy makers have placed on regional economic security in defending damage assessments, it is surprising how little evidence exists to support the contention.

CONCLUSIONS

The state of knowledge regarding the potential direct and indirect losses due to failed lifelines, particularly water systems, is modest at best. It is seldom that the United States experiences disasters on the scale of the earthquake which shook San Francisco in 1906. What we know about such events is outdated and inapplicable to modern systems. It is clear that much of the published research reviewed is highly conjectural, being founded more on orchestrated sets of assumptions than on fact. This is not necessarily the fault of those writing on the subject; it is just that experience is rare and it is tempting to fill the void with elaborate models. For this reason it is important to glean as much evidence from the few events occurring worldwide each year as is possible.

A great deal of care must be exercised in interpreting the literature. We believe that secondary losses, employment effects, produced from water supply interruptions are probably overstated. We have not been able to uncover any evidence that such disruptions have prolonged recovery or produced extreme economic hardships. This does not mean, however, that extreme events could not present new challenges which result in significant indirect effects. Evidence simply does not support the conventional wisdom.

There appears to be ample opportunity for improving the conceptual framework, delineating conditions which should exist before the federal government becomes involved in relief operations. First of all it is not clear that aid should be provided without a clear understanding that national and/or regional interests are jeopardized. Put crudely, it should be demonstrated that the additional information afforded by a damage assessment system is worth the expense incurred in its development and maintenance. At the very minimum, water supply damage assessments should be tied to other projections to determine if water is the constraining element in the economy.

It would appear that aid should be provided in direct proportion to the difference between postdisaster demand and supply. It made little sense, for example, to hasten the repair of Darwin's water and sewage system when the extensive destruction to residential neighborhoods forced every two out of three people to evacuate to another city.

Lastly, we find it difficult to support the index system approach to hazard analysis proposed by FEMA (Integrated Emergency Management System). The catagories are vague and highly subjective. As a result it is unclear how such an assessment could be of value to either federal agencies in planning aid or to the public works departments which must cope with the stresses and immediacy of a sudden emergency.

Overall, the problems we have encountered lead us to believe that predicting the secondary effects of earthquake damage to lifelines will be very difficult. Earthquakes in major metropolitan areas have brought surprises because the interrelationships and interdependencies among lifelines and with other facilities are becoming more numerous and complex. Also the form, character, and components of the system have never been tested by a real earthquake.

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APPENDIX A:

EMERGENCY WATER PLANNING ANNOTATIONS

1
Adrian, George W.; Anathol Goldman; and Albert A. Forthal. 1972. Water Quality after a Disaster. Journal of the American Water Works Association 64:481-485.

This article discusses three resources--physical facilities, personnel, and emergency operations planning--that are essential to water utility recovery following a disaster. The response of the Los Angeles Department of Power and Water to the 1971 San Fernando earthquake is reviewed.

Both regular and standby facilities should be provided. Every first-line chlorination station should have an alternate power supply and alternate equipment units. Alternate laboratory facilities should be established and maintained. Portable facilities are useful for increasing the capacity of regular facilities as well as for supplying emergency capability. It is vital that facilities be damage-resistant; considerations should begin at the design stage to reduce vulnerability to vandalism and natural disasters. Structural design safety factors should be more conservative where failures would have severe effects.

Personnel should be thoroughly familiar with normal operating features, maintenance, and repairs. Both on-the-job training and classroom training should be utilized to increase the knowledge and capabilities of utility personnel. Employees should be drilled in emergency procedures so that they know what they are doing and why. Working relationships should be maintained among personnel in different divisions and at different levels to avoid insulation and increase effectiveness in emergency situations. Contacts should be maintained with outside agencies to facilitate a coordinated emergency response.

A flexible emergency plan should be developed to allow the application of judgment and initiative relative to the situation at hand. Communications should be kept simple. Instructions should be written wherever necessary to avoid confusion. All public announcements should be issued from a single source from within the water utility.

The authors provide a detailed account of the Los Angeles water utility's response to the 1971 earthquake, from immediate postdisaster activities to the final recovery several months later.

The article offers clear, concise information that would be useful to water managers in all aspects of emergency planning.

2
Agardy, Franklin J. 1975. Contingency Planning for Water Utilities. Journal of the American Water Works Association 67:159-163.

The article provides practical guidelines for the development of emergency operations plans by water utilities. The author reviews vulnerability analysis and contingency planning procedures.

Natural and technological disasters may have very similar effects on water utility operation. For that reason, contingency plans developed to cope with disaster may have common core components. Disaster is defined as an event, natural or man-made, that is concentrated in time and space and that causes a community or a specific subdivision of a community to suffer danger or disruption of normal functions. The author urges that careful distinctions be made between disasters and routine disruptive operations. Disasters should be analyzed in terms of probability and effect ranging from low-probability, low-magnitude events to high-probability, high-magnitude events. Once the range of potential disasters has been identified, the next steps in utility preparation are to conduct a vulnerability analysis and to develop a contingency plan.

The water supply system can be categorized in terms of collection works, the transmission system, treatment facilities, and the distribution system. Vulnerability analysis provides a delineation of the strengths and weaknesses of system components in relation to specific anticipated disaster conditions. Additional considerations in developing an emergency plan include determination of the postdisaster status of the system, establishment of immediate recovery objectives, implementation of the plan of action, and coordination of activities. The six steps involved in vulnerability analysis are (1) identify and describe the separate components of the water supply system; (2) assign characteristics to the anticipated disaster; (3) estimate effects of the anticipated disaster on each component of the system; (4) estimate water demand, both quantity and quality, during and following the anticipated disaster for all the characteristics of the disaster; (5) determine the functional operation or capability of the water supply system in meeting the demand; and (6) if the system fails to meet the requirements, identify the key or critical components of the system that are primarily responsible. An example is given of analyzing system vulnerability to overt contamination.

Contingency plans should be comprehensive in their coverage of utility operations, yet simple enough to be implemented by operations personnel. An emergency plan should reflect the vulnerability assessment of the individual utility and its regional location, although certain basic elements should be common to all contingency plans. The six basic elements are (1) creation of a contingency response team with detailed instructions regarding responsibilities and asssignments; (2) establishment of a detailed training program for personnel involved in plan implementation; (3) collection of maps of the water utility system, including access roads to remote facilities; (4) an inventory of all equipment available to the utility and of all equipment required for a particular contingency, with information about any chemical stockpiles; (5) a list of local and regional coordination elements; and (6) a plan format that will facilitate regular review and modification activities, such as a looseleaf document which can be readily modified.

The article is informative and well written. The planning guidelines are clear and relatively detailed. Although all basic requirements for vulnerability analysis and contingency plan development are provided, there is no mention made of testing or drilling the contingency plan.

3

Agardy, Franklin J., and Charles A. Froman. 1977. Managing Man-Made Disasters. In Proceedings, American Water Works Association Annual Conference, Paper No. 31-4, pp. 1-18. Denver: American Water Works Association.

In this two-part paper, the authors describe the role of contingency planning in water utility management and offer tools to aid managers in formulating contingency plans and increasing emergency preparedness.

Part 1 presents contingency planning as a dynamic exercise, the goal of which is the optimal utilization of both human and material resources during periods of emergency. Many utilities have plans that are inadequate due to a limited addressment of emergency situations or to the failure on the part of the utility to periodically update, modify, and implement the plan. Most disasters produce very similar effects for water utilities; a well-developed contingency plan deals primarily with disaster effects and prepares the utility for such effects through an active program of design upgrading and modification or through a passive program of material stockpiling, joint agreements with other utilities and agencies, and personnel training. The author discusses contingency planning for work stoppages, which involves identifying the obligations and rights of management; minimum operational manpower requirements; minimum operational material requirements; the rights and obligations of labor; citizens rights under the Safe Drinking Water Act of 1974; and the potential impact on water quality.

Contingency planning is important for the design of new facilities and for strengthening existing facilities. The seven basic steps in emergency operations plan development are (1) state assumptions of emergency-caused effects; (2) estimate remaining capabilities; (3) estimate community requirements; (4) match capabilities to requirements; (5) specify allocation priorities; (6) program the best apparent way of using resources; and (7) assign specific tasks to assumed available personnel. The basic elements of an emergency operations plan include (1) inventory organization and make assignments; (2) conduct vulnerability assessment; (3) specify priorities and program resources; (4) provide personnel protection; (5) inventory communications equipment and plan emergency use; (6) assess protection of plant equipment, inventories and records; (7) initiate mutual aid agreements and other cooperative agreements; (8) determine emergency-phase action steps; (9) plan operational recovery; and (10) correct indicated deficiencies.

In part 2, the author offers management tools to assist water utility managers in managing disaster situations. All of the problems facing management, such as poor communication, bad organizational structure, lack of operational procedures, poor operator training, poor personnel practices, or lack of performance reports, may surface during disasters and must be considered during the development of contingency plans and procedures. Self-evaluation audits can be used to evaluate all of the functions of management and are especially useful in the identification of problem areas in disaster response. An audit developed by the AWWA to address contingency planning for work stoppages is given as an example. The study of disasters that have occurred in other water utilities is an important tool in contingency planning. The experiences of others can provide valuable guidelines for understanding and strengthening emergency preparedness. A bibliography of work-stoppage case histories and contingency plans is given as an illustration.

Written operational procedures are a third tool for effective emergency management. Procedures are defined as sentence outlines of the critical steps of an operation that establish how the operation is to be performed. Written procedures benefit management by reducing the time necessary to train personnel to perform a task, helping to ensure that operations will be carried out in a predictable manner, allowing procedures to be reviewed and revised more easily, and providing a useful record of how a task was supposed to be performed. Examples of written procedures are given. The evaluation of reserve and backup facilities is another important management practice. The study of hypothetical disasters and disasters at other utilities helps to identify the reserve facilities useful and/or necessary in the various disasters considered in contingency planning.

This paper could be very useful in guiding utility managers through the contingency plan development process and in helping managers evaluate their contingency programs.

4

Albertson, Maurice L.; Michael Poreh; and Gregory A. Hurst. 1978. Big Thompson Flood Damage Was Severe, but Some Could Have Been Prevented. Civil Engineering 48(2):74-77.

The authors review the damages resulting from the 1976 flooding of the Big Thompson River and offer recommendations for minimizing future flood damage.

Damages from the 1976 Big Thompson flood were confined largely to three distinct areas: the Narrows upstream from the canyon mouth, the floodplains upstream from the Narrows, and the area downstream from the canyon mouth. Damages to roadways, buildings, and other structures were severe. Damages resulted not only from the flow of the river but also from boulders, rocks, trees, vehicles, houses, sediment, and other debris being washed into the river. Most of the houses that were washed away either did not have adequate foundations or were not anchored to the foundation. An inverted siphon across the river at the mouth of the canyon collapsed due to the loss of an unachored pier. Erosion and scour caused extensive damage to roadways, foundations, and structural piers. Rock slopes and riprap installed to protect against normal flooding conditions could not withstand the extreme flows which resulted in severe scouring, except in one case where rock had been hand-placed into a smooth, interlocking pattern offering little resistance to the river flow. In the Narrows, nearly the entire roadway was washed away. The diversion and storage dam for a hydropower plant several miles upstream failed because scour at the north end caused undermining and eventual collapse. The dams surviving at the end of the Narrows were masonry arch dams that permitted the free flow of water over them. Damage was most severe at the mouth of the canyon; the Bureau of Reclamation Colorado-Big Thompson water project lost all ability to place water into or across the Big Thompson River. A list of damages and of emergency operation procedures initiated by the Bureau of Reclamation is given.

During the first week after the flood, recovery efforts included a survey of damage to federal and private water and power facilities and the preparation of a power system contingency plan. Full power service was maintained to nearly 100 preference power customers throughout the crisis, and full supplemental water service was restored to about 200,000 irrigated acres and to many muncipalities along the river without crop damage or serious water shortages occurring. Steps to minimize future flooding damage include preventing floodplain development, anchoring existing structures to massive foundations, using reinforcing steel whenever concrete blocks are used, and protecting highway embankments from the destructive forces of floodwaters by installing properly constructed riprap or by anchoring retaining walls to canyon walls. The author acknowledges the expense required for such protection but advocates the comparison of protective measure costs against the costs of rerouting the entire highway away from the flood zone. A flood warning system that can operate during power and telephone failures is of great importance; many lives could be saved by such a system although it would do little to reduce property losses.

The article providès a summarization of Big Thompson flood damages and potential mitigation measures, although there is no particular emphasis on the impacts of the flood on area water supply systems.

5

American Water Works Association. 1985. Flooding Sets Path for Spring in Peoria. Mainstream 25(5):1,13.

This article describes an Illinois utility's response to severe flood threat.

In March, 1985, the Illinois-American Water Utility of Peoria, Illinois, was faced with near-record flooding that threatened its Peoria River treatment station. The flood, which missed the 1943 record by only 0.4 foot, caused $3.9 million in damages. The treatment plant's seawall at the river intake is 26 feet, and the pumps on the intake platform are at 30 feet. When the rising waters pushed over the seawall onto the grounds of the Illinois-American facility, the intake was isolated and the main road and entrance gate were flooded. The utility immediately activated its flood emergency plan. Trucks brought in loads of sand, sandbags, plastic, and hoses. Sump pumps were purchased, and 2,000 sandbags were filled. More than 500 feet of plastic was used. With an around-the-clock shift, the critical buildings--two pump houses and the open main well--were secured. The company continued normal operations until the river crested at 28.4 feet. The river intake was closed when threatened; water was supplied from the main well and other sources.

Sandbags were left in place to guard against further spring flooding; the river had flooded four out of five years. The city plans to use a $250,000 federal allocation to study how to recontour the river valley.

6

American Water Works Association. 1985. Hurricane Gloria Tests Eastern Utilities' Emergency Plans. Mainstream 29(11):1,5.

The article describes the emergency response of water utilities along the Eastern seaboard to Hurricane Gloria.

Hurricane Gloria reached landfall on Friday, September 27, 1985. Utilities had ample warning to implement emergency plans; the storm had been upgraded to hurricane status six days earlier. The hurricane had nearly reached category 5 status--the most severe classification--but was diminished by cool, dry air from the continent. Water utility preparations had included checking backup power capacities, stocking supplies, assigning crews and equipment, drawing down reservoirs, filling water storage tanks, and identifying key emergency response personnel and responsibilities.

The eastern area had been suffering from drought, which meant that water levels in rivers and reservoirs were already low. This prevented the extensive flooding that would have occurred if the hurricane-induced rains and storm surges had confronted full water levels. Under normal conditions, the rains would have inundated watershed areas and pumping stations. Utilities topped off their clear-water storage tanks in order to maintain pressure and to provide continuous supply in the event that the storm disrupted operations at treatment plants. In Virginia, customers were asked to fill tubs, sinks, and containers for potable supply storage and, under a declared state of emergency, were requested to conserve water until the hurricane had passed. Several utilities prepared for special treatment problems with high surface-water turbidities by maintaining extra chemicals on hand, closely monitoring water quality, and shifting operations to sources with lower turbidities. Record rainfalls in Pennsylvania resulted in a hazardous materials spill into the Susquehanna River, apparently from the flooding of a mine drainage site. The Pennsylvania Department of Environmental Resources implemented a response plan that included notifying officials of communities downstream, as well as the U.S. Environmental Protection Agency's Superfund office. The oily substance remained on the surface and did not affect downstream users.

Several utilities reviewed the success of their emergency plans, with improvements planned that include strengthening communication links and backup, ensuring a dependable food supply for field crews during emergencies, and developing backup generating capacities. Most utilities were pleased with the success of their emergency plan implementation.

The article provides an informative review of the performance of various utility emergency operations plans.

7

American Water Works Association. 1984. Emergency Planning for Water Utility Management. AWWA Manual M19, 2nd ed. Denver: American Water Works Association.

The manual reviews potential disaster effects on water supply systems and provides a comprehensive guide to the emergency operations planning process, with a substantial bibliography of pertinent literature.

In the United States, water utilities may be affected by a wide range of natural and human-induced emergencies. In preparing for emergency, a water utility has four subsystems to consider: (1) collection, (2) transmission, (3) treatment, and (4) distribution. Within each are critical components, such as power, personnel, materials and supplies, that must be evaluated in developing an emergency plan. Disasters may be broadly classified as natural disasters, disasters caused by accidents, and disasters caused by deliberate action. Specific effects of natural and man-made disasters are discussed. A disaster effects matrix reveals that effects from various disasters may be very similar.

Vulnerability assessment is described, steps in conducting a vulnerability analysis are given, and examples of vulnerability assessment are displayed. The six steps in conducting vulnerability analyses are (1) identify and describe separate components of the water supply total system; (2) assign characteristics to the designed disaster; (3) estimate effects of the designed disaster on each component of the system; (4) estimate water demand, both quantity and quality, during and following the designed disaster; (5) determine, by critical review and analysis of information developed in step 3, the functional capability of the water supply system in meeting the estimated requirements; and (6) if the system fails to meet the estimated requirements, identify the key or critical components of the system that are primarily responsible.

Protective measures fall into two categories: design considerations and response functions. Countermeasures are listed for five high-probability effects: contamination, power outages, communication disruption, transportation failure, and plant damage. General protective measures include limiting access to watershed areas, adequate structural design of reservoirs and storage tanks, automatic valves to close and isolate main breaks, and development of multiple water sources--surface and underground. Personnel protection represents a key element of the emergency planning process.

Basic principles of emergency operations planning are (1) the operations plan considers only existing resources; (2) the operations plan should be as concise as possible, in language familiar to the person in charge; and (3) the operations plan should not be overly detailed. Guidelines to creating and implementing emergency plans include: (1) review the organization and make assignments; (2) make vulnerability assessments; (3) specify priorities and program the best apparent way of using remaining resources; (4) provide personnel protection; (5) inventory communications equipment and plan emergency usage; (6) assess protection of plant inventory, equipment, and records; (7) initiate mutual aid and other cooperative arrangements; (8) determine emergency-phase action steps; (9) plan postdisaster, operational recovery operations; and (10) plan for improving the capability of the system as indicated by deficiencies. Special emphasis should be placed upon facility security as part of emergency operations planning.

Emergency operations plan implementation primarily involves personnel training. A training program must have purpose, supporting materials, proper instruction, and appropriately selected trainee personnel. Training elements include the selection of trainee personnel, the evaluation of existing training courses, the performance of a skills inventory for all utility personnel, the design of training exercises, and the maintenance of an ongoing training program. The specific components of a training program will depend on (1) size of utility; (2) location; (3) complexity of the facility; (4) type of staff; (5) critical nature of utility operation; (6) availability of existing training programs; (7) type of instructors available; (8) educational level of staff; (9) type of disaster possible; and (10) possibility of joint-training program with neighboring utilities and other area governmental agencies.

The first appendix presents a complete discussion of the threat from the addition of chemical or biological agents to a municipal water supply. The relative toxicity of various materials is described, along with protective measures and emergency countermeasures. Other appendices contain a listing of commonly used "10" signals in radio communication (e.g., "10-4," which indicates a message received), and an illustrative procedure form for recording bomb threats or other anonymous phone calls.

The manual offers a thorough, well-organized approach to emergency plan development, with useful background information relevant to disaster management. The manual would be very valuable to water utility management and to engineers involved in water system design.

8

American Water Works Association. 1984. Nine Words Used to Bridge Receding Waters. Opflow 10(7):1,7.

This article discusses nine actions that aid water utility managers in coping with water shortages.

Emergency planning is an essential part of water utility operation. Nine words can help managers prepare for water shortages: Communicate. Utilize local radio and TV stations to educate the public and seek public cooperation. Motivate. Make employees aware of the significance of the situation and enlist their support in advising customers against wasting water. Make sure that crews have the proper identification and instruct them in the approach and message they are to use in communicating with the public. Monitor. All sources of supply as well as the storage facility must be monitored. The health of a groundwater system can be gauged by the relative static and pumping water levels. Conserve. Establish codes that ban inefficient plumbing fixtures. Most importantly, educate the public in the need for water conservation. Enforce. Codes and ordinances that protect water supply must be enforced. Make sure that ordinances enable utilities to enlist the local police department to assist with citizens who insist on wasting water. Repair. Repair the cause of system shortage; if the system is down due to an erroneous decision or faulty procedure, then these must be corrected, as well. Research. Know the water system's history and evolution. Gather records and drawings, develop a catalog of all facilities, and compare pumping volumes with consumption volumes. Plan. Develop crisis management techniques and plan responses to various degrees of shortage. Fund. Apply state-of-the-art technology throughout the system; the most economical way to use manpower is to adopt labor-saving equipment, such as telemetry systems. The best time to obtain funding and ongoing financial commitments is during a water shortage.

This article could be useful to water utility managers in their efforts to develop water shortage contingency plans.

9
American Water Works Association. 1984. Roundtable--Is Vandalism a Threat to Water Utilities? Journal of the American Water Works Association 76:19-30.

The roundtable discussion was initiated to assess the threat of vandalism to water utilities and to explore possible measures for coping with the threat. This article is transcribed from the roundtable discussion held at the 1983 AWWA Annual Conference in Las Vegas, Nevada.

The primary issues addressed at the roundtable discussion were the frequency of vandalism, the effects of publicizing threats or acts of vandalism, and the status of legislation penalizing such acts. The number and frequency of acts of vandalism are not known; no effort has been made to catalog these occurrences. Several participants expressed concern about possibly adverse effects of publicizing threats or vandalism, such as increased occurrences (copycat acts) or panic among utility customers. In 1982, chlordane was deliberately introduced into the distribution system of a Pennsylvania utility during a labor dispute. The public remained concerned about water safety for six months after full, safe service was restored. A counterpoint was made that the discovery that a utility withheld information would be disastrous for the utility; litigation has already resulted from such instances, and it would be far more injurious to public relations than would a contamination scare. In many states, threats or sabotage to a public water system is not penalized by law. Roundtable participants agreed that the presence of such legislation would offer utilities assistance in investigating and resolving such incidents. Additional concerns included system security and the preparation of a comprehensive, nationwide emergency planning manual to complete the information offered in the AWWA Emergency Planning manual. This effort would include the formulation of an extensive emergency operations database.

The article offers insight into industry concerns about possible vandalism or terrorism aimed at public water supplies and highlights the absence of a uniform policy to cope with such events.

10
American Water Works Association. 1984. Voluntary Emergency Assistance Plan. Opflow 10(7):6.

This article describes the formation of an emergency assistance clearinghouse among Arkansas water utilities.

In December, 1982, tornados and rainfalls of 4-14 inches in 24 hours damaged an area covering nearly one-third of the state of Arkansas. Water intakes, water treatment plants, and wastewater treatment plants were flooded, and roads, bridges, power lines, and waterlines were washed out. Over 40 community public water systems lost pressure in part or all of their distribution systems. Most systems were able to restore normal service within a few days; however, several systems were damaged so severely that they lacked the manpower, equipment, and materials needed to restore service. Several systems that did not suffer damage volunteered their assistance, sending materials, equipment, and crews to the crippled utilities. The Division of Engineering of the Arkansas Department of Health oversees the Arkansas Public Water System Supervision Program. In assessing the disaster, the Division of Engineering felt that existing emergency plans were inadequate to handle disasters of that scale, and, having noted the willingness of many systems to provide assistance during emergencies, decided to establish an emergency assistance clearinghouse to be operated by the Arkansas Department of Health. The clearinghouse would depend upon voluntary assistance and would supplement services provided by the state Office of Emergency Services.

The establishment of an adequate statewide communications system was necessary, as was the establishment of a large resource pool to provide manpower, materials, and equipment. The Department of Health had a statewide radio network and a 24-hour communications center that could be used for the clearinghouse. As funds become available, two-way radios will be installed in the vehicles of clearinghouse support personnel. The resource pool was developed by mailing questionnaires to all community public water systems. All participation was to be strictly voluntary, and systems were advised to obtain the approval of their governing body before responding to the questionnaire. The information requested included (1) primary and alternate contact persons and telephone numbers; (2) whether or not reimbursement would be required for the cost of any assistance provided; (3) geographic area where assistance could be provided; and (4) a brief description of equipment, materials, and personnel that could be provided. The questionnaires yielded over 160 responses, primarily from medium-to-large utilities that would be most likely to have the resources to provide the needed assistance. Demands for emergency generating equipment can be handled only by the National Guard and local Civil Defense organizations.

The article could be very useful to water utility managers in their efforts to increase emergency preparedness, particularly to small water systems that may not have sufficient emergency resources.

<u>11</u>

American Water Works Association. 1983. California Water System Survives Earthquake Intact. <u>Mainstream</u> 27:1,2.

This article describes the impacts of an earthquake on the community's water supply system.

In May, 1983, an earthquake measuring 6.5 on the Richter scale caused extensive damage to the town of Coalinga, California. Structural damage to buildings in the downtown area was severe, but the community's water system sustained only minor damage. The California Aqueduct, one of the state's major water supply lines, is located only 15 miles from Coalinga. The California Aqueduct was designed to be earthquake-resistant and was only slightly damaged in the tremor.

The Coalinga water system sustained numerous small leaks in the distribution system; crews began repairing leaks within a few hours of the earthquake and worked around the clock for a week to restore distribution lines. A chlorinator received minor damage but remained fully operable. A 7.5 mil gallon storage tank, half-full when the earthquake struck, remained undamaged. Although there was never any evidence of contamination, the public works director advised residents not to drink the water for a week following the earthquake. Brewing companies in a neighboring community voluntarily bottled water and trucked it to Coalinga, supplying more than enough to meet potable water requirements for the week. At the time of the earthquake, Coalinga did have an emergency plan for earthquakes; a drill to test the plan had been scheduled for June 1, less than a month after the earthquake occurred. Most of the town's supervisory personnel were aware of the emergency plan's provisions.

12

American Water Works Association. 1983. Handling the Threat of Contaminated Water Supplies. Opflow 9(3):1,4.

The article, adapted from the AWWA Manual M19, Emergency Planning for Water Utility Managers, describes contaminant toxicity; suggests protective measures for water supplies; and provides a list of treatment measures for counteracting contamination.

Toxicity is defined as the ability of a contaminant (chemical or biological) to cause injury when introduced to the body. The degree of toxicity varies with the concentration of contaminant required to cause injury, the speed with which injury occurs, and the severity of the injury. The effects of toxic contaminants in a water supply depend on the amount of contaminant added, the solubility of the contaminant, and the detention time of the contaminant in the water. An acute toxic agent causes illness in a matter of seconds, minutes, or hours after a single exposure or dose. A chronic agent causes injury to occur over an extended period of time and is generally ingested in repeated doses over a period of days, months, or years. The effective dosage of a contaminant depends on (1) the quantity or concentration of the contaminant; (2) the duration of exposure to the contaminant; (3) the physical form of the contaminant; (4) the attraction of the contaminant to the organism being contaminated; (5) the solubility of the contaminant in the organism; and (6) the sensitivity of the organism to the contaminant. Concentration of a contaminant can be expressed as a maximum allowable concentration (MAC), which is the maximum concentration allowed in drinking water, or as Lethal Dose 50 (LD 50), which represents the concentration of a contaminant that will produce 50 percent fatalities from an average exposure.

Countermeasures that increase the protection of a water supply include (1) maintaining a high chlorine residual in the system; (2) retaining engineers, chemists, and medical personnel on a 24-hour alert; (3) continuously monitoring key points in the distribution system; (4) increasing security around exposed on-line reservoirs; (5) sealing off access to manholes within a three- to six-block radius of highly populated areas; (6) establishing emergency crews that can isolate sections of the distribution system; and (7) staffing the treatment facility on a 24-hour basis. If a contaminant has entered the distribution system, immediate public notification is the highest priority. Alternate sources may need to be provided. If the contaminated water has not entered the distribution system, it may be possible to isolate the contaminated source. Treatment measures may be available to remove the contaminant or reduce its toxicity. Emergency treatment methods are effective only if the contaminant has been identified. A table is given that lists emergency treatment measures of specific chemicals, which include arsenicals, cyanides, hydrocarbons, miscellaneous organic chemicals, nerve agents, and pesticides.

The article provides valuable information to assist water utilities in the development of contamination contingency plans.

13

American Water Works Association. 1983. Houston Utility Takes Hurricane in Stride. Mainstream 27(10):1,5.

This article describes the impacts of a hurricane on the Houston municipal water utility.

On August 18, 1983, Hurricane Alicia hit Houston, Texas, with 90-mph winds. The public water system credits their emergency plan for their ability to maintain service throughout the storm. Although there was no evidence of contamination, customers were advised to boil their drinking water as a precautionary measure. Falling trees damaged several power lines, resulting in lowered water pressure. At the height of the storm, out of 12 major pumping stations, 3 remained online, and 4 out of 117 wells remained operative. The city water division had established a priority listing with the electric utility as a part of their emergency planning process, allowing them to work directly with the electric utility throughout the storm in restoring power as rapidly as possible. In preparing for the hurricane, all elevated tanks were filled to capacity to help withstand high winds, and the chlorine residual in all ground storage tanks was raised to 3 parts per million. An emergency operations headquarters was established at the water system's computerized central control unit.

Communications were the biggest problem; several radio base units became inoperable due to weather conditions. Mobile radio units were dispatched to replace the base units. The utility plans to station mobile units near base units in the future to prevent lengthy delays in communication.

The article provides an informative description of the ongoing adaptation of a coastal water system to the threat of hurricanes.

14

American Water Works Association. 1983. Louisiana Water Systems Receive Cyanide Threats. Mainstream 27(3):5.

This article addresses a series of threats of water supply poisoning directed at utilities in Louisiana.

In January, 1983, more than 50 communities and water utilities in southern Louisiana received telephone calls warning of the poisoning--usually by cyanide--of their water systems. Under laboratory testing only one community supply revealed traces of cyanide. The water supply of Hammond contained harmless amounts of the chemical, but officials were unable to determine whether it had been deliberately introduced or had resulted from naturally occurring conditions.

Utility response to the threats varied widely. Some utilities discontinued operations and trucked in emergency supplies. Others increased chlorine additions to neutralize any possible cyanide and informed the public of the actions taken. The Louisiana State Health Department was aware that issuing public warnings might induce additional threats but decided that the public's right to know outweighed the risk of encouraging copycat behaviors.

The article refers the reader to the AWWA manual M19, Emergency Planning for Water Management, for further information on preparedness and response for such contingencies and notes that the AWWA Water Utility Council decided in 1982 to endorse legislation that would provide a federal mechanism for prosecuting someone who tampers with finished water supplies. The council prefers that this legislation and any ensuing prosecutions be handled as quietly as possible to avoid encouraging either threats against, or actual sabotage of, water systems.

The article illustrates the complexity of the decision to openly address a public threat when such publicity might exacerbate the threat. The necessity of weighing the public's right to information against any potentially adverse consequences is an important consideration in the development of response procedures by community water supply managers.

15
American Water Works Association. 1980. News of the Field--Water Supply in Manson, Iowa, Restored Rapidly with Emergency Makeshift Chlorinator; Groundwater Pumping Can Raise as Well as Lower Land Surface. Journal of the American Water Works Association 72:88-89.

The article describes the provision of emergency water supplies following possible contamination of supplies after a tornado. The author recounts the case history of a stricken community in Iowa.

On June 29, 1979, Manson, Iowa, was hit by a tornado that left the water utility to cope with service and line breaks, a loss of system pressure, more than 100 cubic yards of debris strewn over the cover of the ground-storage reservoir, and suspected backsiphonage. Some of the damaged or destroyed facilities held stocks of pesticides, and damaged pesticide containers were scattered throughout the city. The tornado downed electrical transformers, and it was feared that coolant leaking from the transformers could be seeping into the water supply, adding the possible threat of PCB contamination to an already critical situation; however, the transformer coolant was a highly refined petroleum product rather than the suspected PCB. Tests showed no organic pesticide contamination, but bacterial contamination was present. The water supply had no disinfection treatment, so that system personnel had to devise treatment. The first effort involved dissolving chlorine granules in 30-gallon garbage cans and emptying them manually into the reservoir. The water supply then obtained the use of a 500-gallon capacity pumper unit from the city fire department to serve as a makeshift chlorinator. The National Guard supplied the town with an emergency potable water supply and requested that residents curtail water usage. Complete potable water service was restored to the residents within one week of the tornado. In order to prevent a future emergency makeshift operation, a hypochlorinator was installed on July 2, 1979.

The article is brief and focuses primarily on the postdisaster disinfection problems facing the utility. Other effects of the tornado on the water utility are not detailed.

16
American Water Works Association. 1979. Emergency Operations under Disastrous Conditions--Do You Have a Plan? Opflow 5(8):4-5.

This article emphasizes the importance of emergency operations planning to water utilities and offers suggestions for the planning process and an outline on which to develop a plan.

No water utility should be without a plan. An important function of an emergency plan is to reduce the number of decisions that must be made under disaster conditions by providing for the orderly initiation and implementation of predetermined measures. In many disasters, a water utility's priorities are (1) to provide water for fighting fires; (2) to prevent unecessary loss of stored treated water; (3) to develop and maintain adequate amounts of potable water; and (4) to restore the entire system as soon as possible. The public must be kept informed, and the demand met for supplies of emergency potable water, which will drop sharply during the initial restoration period and increase as normal activities are regained. Implementing an emergency plan requires employee training. All utility employees should be evaluated for the presence of extra skills gained through previous training, employment, or hobbies.

A good emergency plan is short and simple and provides control of unscheduled problems in the water system even in the absence of top managerial personnel. Formulating and updating the plan provides an opportunity to highlight the importance of the utility and its daily operation and maintenance. All water utility personnel and key local officials must be familiar with the plan. A detailed outline for the development of an emergency operations plan is given.

The article could be useful to water utility managers in their efforts to initiate the emergency planning process.

17

American Water Works Association. 1979. If Disaster Strikes--Are you Prepared? <u>Opflow</u> 5(9):1,6.

The article describes the response of a municipal water utility to system damages resulting from a tornado.

On the evening of June 28, 1979, a tornado severely damaged Algona, Iowa, which obtains its water supply from five gravel-packed wells. Algona Municipal Utilities (AMU) personnel immediately reported to headquarters. The tornado interrupted electrical service to the entire city; an emergency gas-driven, high-service pump was employed to maintain water supply until full power was restored to the utility. Continuing decreases in system pressure alerted the utility to begin field checks of the entire system. Numerous service lines and one hydrant were damaged. In addition, volunteers operating debris-removal equipment during rescue operations damaged several services that had escaped damage by the tornado. Many of the homes destroyed were located in an area equipped with a remote meter-reading system and all remote receptacles were lost.

The presence of a large inventory of water supplies such as meters, meter parts, fittings, and copper service pipe proved to be of great value in facilitating the repair and restoration effort. The Iowa Department of Environmental Quality regional office sent a team to monitor water quality at several points in the distribution system and to assure that the water was safe for consumption.

Although basic emergency preparedness measures had been adopted by the utility prior to the tornado no thought had been given to the issue of meter readings for billing purposes. The utility chose to estimate each customer's bill in the disaster area based on the lowest consumption recorded during the past year and to prorate the billing.

This article illustrates the importance of including the financial and administrative functions of water utilities, such as bill estimation procedures, in the overall emergency planning effort.

18
American Water Works Association. 1975. Hazardous Materials Spills Emergency Handbook. Denver, Colorado: American Water Works Association.

This manual is designed to provide information to assist water utilities in preventing hazardous materials spills, preparing to respond to spill situations, familiarizing utility personnel with hazardous materials and procedures for their removal, and locating spill response programs capable of assisting utilities in the event of an emergency.

The manual offers the opportunity in each section to enter information specific to the user, so that a practical, individualized document may be created. An emergency action bulletin is provided which consists of the names and telephone numbers of critical response agencies.

The importance of conducting periodic vulnerability analyses is stressed, and vulnerability survey guides are included to assist water utilities in making such analyses. The vulnerability survey guides relate to railroads, highways, pipelines, waterborne transportation, and fixed-storage spills. Each utility is cautioned to place particular emphasis on the sources of pollution present in local areas, and to add additional items to the survey form to cover all potential problems for that utility. The manual notes the usefulness of mapping the locations of significant exposures to hazardous materials, past spill occurrences, and equipment and materials needed for response. No survey is included for an air crash contingency due to the low probability of such an event seriously affecting a watershed; however, suggestions for response are provided in other sections of the manual.

Preparations for spill emergencies include suggestions for arranging for personnel and materials, arranging communication with transportation and storage companies who handle hazardous materials, and arranging for periodic reviews of emergency procedures. A typical local response plan is presented as a guide. The purpose of the plan is to establish a procedure to direct and coordinate the efforts of water utility and contractor personnel in the event of a hazardous material spill in any location that could affect water supply operations. A hazardous material spill is defined as any significant discharge of a hazardous material from any manufacturing or storage facility or pipeline, truck, ship, or other conveyance, whether accidental or otherwise, in an area where said material could gain access to the surface or underground supply or the distribution system of the water utility. Plans and policy formulated at the national level are described, as are the CHEMTREC plan and the Pesticide Safety Team Network, to provide utilities with information on existing planning and preparedness systems.

A listing of the general classes of materials that may be hazardous to water supplies is given, and recommended removal methods are presented for each hazardous materials class.

This manual provides a concise, informative, practical guide to hazardous materials spill planning that would be useful to any utility or local agency concerned with the maintenance of water supplies.

19

American Water Works Association. 1954. Design and Operation of Chlorination Stations under Normal and Emergency Conditions. Panel Discussion. Journal of the American Water Works Association 46:869-893.

This title introduces two technical articles which consider the practical design factors for chlorination stations, operating problems, and emergency chlorine supplies. The problem of emergency chlorine supplies in the Pacific Northwest is presented in the context of civil defense planning to cope with a major disaster. The focus is on the potential chlorine and container supply during a disaster when demand for the chemical is unusually high and the three chlorine-producing plants in the area are destroyed or shut down due to lack of electrical power, essential raw materials, or other supplies.

The demand for chlorine in the Pacific Northwest was expected to increase from 120 to 200 tons per month during normal times to 500 tons per month in a major emergency. In addition, if biological warfare were used, the need for chlorine as a decontaminant could easily double. The three chlorine plants in the area did not customarily store more than four to six day's capacity output and usually had only 10 percent of the several thousand chlorine cylinders and ton containers on their premises. The reserve chlorine supply under the most unfortunate and extreme circumstances was estimated to meet the demands for two months. These reserves would be available in tank cars at industrial plants and in transit on rail lines. Water utilities under normal conditions maintained a supply of chlorine representing a reserve sufficient for a week of normal operation.

The article considers in greater detail the technical problems of distributing the reserves of chlorine to water utilities in the areas of emergency. Also, the author suggests that the manufacture and distribution of hypochlorite solutions in time of emergency would be possible through the facilities used at pulp mills or by mixing lime with liquid chlorine. In the absence of gas chlorinators, the hypochlorite equipment would offer a simple means of chlorination.

20
American Water Works Association. 1951. Water Supply Notes on the Kansas Flood. Journal of the American Water Works Association 43:681-688.

The article provides a city-by-city description of the impacts of extensive flooding on the water supplies of nearly 50 Kansas and Missouri communities.

Power outages were extensive, resulting in pumping station and well field failures. Many facilities were inundated, and wells were flooded in several communities. Communities that had supplies in elevated storage were able, in most cases, to survive by rationing the stored supplies until full water service was restored. Many towns had water trucked in from outside the service area until water service was resumed. State board of health purification units were flown in by the Air Force to areas cut off from land access, and emergency treatment units were furnished by the U.S. Army Corps of Engineers and operated by state health department personnel. No mention is made of water supply contamination incidents in any of the affected communities.

The consequences of the Kansas floods revealed three significant points: (1) the large number of plants crippled by power failures indicates the need for attention to power supplies and auxiliary power systems; (2) elevated storage enabled many communities to survive several days of water service interruption, indicating the importance of a reliable emergency supply; and (3) the fact that many water plants and clear wells, which could have been built out of the river valleys, were under five to ten feet of water suggests that designing engineers and regulatory bodies examine their plant location policies.

The article provides a detailed review of the impacts of regional flooding upon area water services.

21
Anton, Walter F. 1978. A Utility's Preparation for a Major Earthquake. Journal of the American Water Works Association 70:311-314.

The author portrays a utility's adaptive response to earthquake hazard. The article reviews the East Bay Municipal Utility District's actions to minimize the effects of earthquake.

The author describes the East Bay Municipal Utility District (EBMUD) operations and the major fault areas that threaten EBMUD facilities. Following the damaging San Fernando earthquake of 1971, the utility took several steps to increase earthquake resistance, including establishment of backup facilities, power supplies, and water supplies; modification of planning criteria and design standards; evaluation of seismic adequacy of existing systems with seismic strengthening modifications undertaken or planned; planning for internal repair capability; increasing cooperation with other utilities (including installation of emergency interconnections); preparing dam failure inundation maps; and emphasizing the provision of sufficient water supplies to meet increased fire-fighting demands after an earthquake. The author lists numerous specific advance preparations and modifications to existing facilities, as well as procedures for the review of a system's seismic adequacy and strengthening.

The article is concise and informative and offers specific information for the adaptation of a water utility to seismic threat.

22

Appleyard, Victor A. and Hugh W. Hetzer. 1973. Joint Discussion--Utility Emergency Planning Pays Off: Flooding in Chester, PA. Journal of the American Water Works Association 65:480-481.

The authors describe the impacts of flooding upon the Chester, Pennsylvania, water system and offer recommendations for future emergency responses.

The Chester Water Authority supplies 30,000 customers from the 30-mgd Octoraro Treatment Plant, with industrial users requiring 60 percent of plant output. Water is conveyed, primarily by gravity, about 40 miles from the plant to the city. In September, 1971, 15.5 inches of rainfall fell near the center of the watershed, producing a record flood in Chester Creek. Only two main breaks occurred during the flood period, neither of which was located in the flooded area. The Pennsylvania Department of Environmental Resources collected 36 samples throughout the city of Chester, 19 of which were positive. On the same day, the Chester Water Authority collected seven samples from the city's system, all of which were negative. Based on the positive samples, the Department of Environmental Resources ordered the Chester Water Authority to issue boil-water notices until released by the Department. The authors maintain that the state sanitary engineer's office did not attempt to locate the source of pollution, nor did it question state sampling techniques or laboratory procedures in view of the contradictory sampling results. The state office required that all water be boiled, even that of the treatment plant 40 miles away.

A temporary lab was established in Chester to monitor chlorine residuals and to collect bacteriological samples by both utility and state personnel. Two residential sections that sustained severe flood damage were isolated from the remainder of the system by closing distribution valves and allowing water to flow in one direction only. Mains and services in the two damaged areas were superchlorinated, and a cross-connection survey was conducted that produced negative results. The Army Corps of Engineers moved in to restore levees, clean up roadways, and remove flood debris. Drinking water for emergency and hospital personnel was supplied in cardboard cartons by a local dairy.

The authors recommend that bacteriological practices in keeping with Standard Methods be established and that personnel be very carefully trained in sampling techniques and processing. Emergency disaster planning should be developed by every water system, with cooperative agreements for state and local agencies, local utilities, and equipment or supply manufacturers. Such planning should include manpower, equipment, and authorization for emergency expenditures.

The article is informative and could be useful to the development of emergency water operation procedures.

23

Barnhard, Lynn Marie. 1984. Earthquake Hazards to Domestic Water-Distribution Systems in Salt Lake County, Utah. Master's thesis, University of Colorado.

The objective of this research is to map potential earthquake-induced geologic hazards and evaluate their effects on the potable water supply and distribution system of Salt Lake County, Utah. The results of this investigation are intended to serve as a general guide for the identification of high hazard areas for water system planning and emergency preparedness.

Four earthquake-related geologic hazards are discussed in terms of their effects on water systems:

(1) Fault-movement damages include shearing of pipelines and wells; cracking of interiors and/or exteriors of buildings such as concrete purification plants; and toppling of structures such as pump facilities and tanks. Pipelines are particularly vulnerable to fault movement and may shear both above and below the ground surface.

(2) Ground-shaking damages include breaking or shearing of pipes or pipe connections; cracking of unreinforced concrete or adobe buildings; rotation of well casings and possible changes in well water levels; and general loosening or breaking of connective apparatus. Ground shaking is usually responsible for the most widespread damage during an earthquake. Underground facilities may be slightly less vulnerable to ground shaking than are the same aboveground facilities.

(3) Soil-liquefaction damages include buckling, tilting, and cracking of structures, and the breaking or cracking of pipes and outlet connections due to differential compaction of liquefied soils.

(4) Slope failures include falls, slides, flows, topples, and lateral spreads and can result in extensive damage to buildings, dams, telephone and powerline supports, pipelines, and aqueducts.

Eight water system components are evaluated with respect to their vulnerability to a magnitude-7.5 earthquake: (1) water purification facilities, (2) major aqueducts, (3) pumping stations, (4) deep-pump wells, (5) aboveground water tanks, (6) underground water reservoirs, (7) penstocks and flumes, and (8) distribution mains. The evaluations are conducted using design and construction data from the facilities studied and by formulating projections with information taken from the earthquake engineering literature. Assumptions are clearly stated. Potential effects are given for component facilities within the study area.

This study provides a useful illustration of seismic vulnerability analysis for community water systems.

24

Bell, Carlos, G.; Harold A. Thomas; and Barnet L. Rosenthal. 1954. Passage of Nuclear Detonation Debris through Water Treatment Plants. Journal of the American Water Works Association 46:973-986.

Following nuclear explosions, fission products may rise thousands of feet into the air and travel long distances with the movement of air masses. Five out of 24 explosions conducted from November, 1951, to June, 1953, in Nevada resulted in a radioactive fallout in Massachusetts, causing the radioactivity of surface waters to increase significantly above natural levels. Large radioactive particles (22 microns in diameter) were discovered at the Oak Ridge National Laboratory in Tennessee. However, significant increases in radioactivity in streams occurred only when precipitation took place in the presence of radioactive air masses.

The authors of this article present and analyze data on the efficiency of removal of radioactive fallout at three water filtration plants which were located in Cambridge and Lawrence, Massachusetts, and Rochester, New York. Approximately 2,200 samples were obtained from various treatment stages of the three water plants and were tested for beta and some gamma radiation. The measurements show that within about two weeks after a nuclear detonation in Nevada, approximately 45 percent of the gross long-range fallout radioactivity in raw water entering each plant passed completely through rapid sand filters.

During the period from two to ten weeks after detonation about 53 percent passed through the plant, and for periods beginning at least ten weeks after detonation practically all the radioactivity (both natural and fallout) passed through the plants. In every instance the measured activities did not exceed the emergency levels set for radioactivity in water containing bomb fission debris.

The methods and equipment used in this study were considered appropriate for measurement of radioactivity caused not only by fallout but also by reactor wastes, accidental spills into surface water supplies, or contamination due to sabotage.

25
Bell, Frank A. 1975. Emergency Supplies. Journal of the American Water Works Association 67:167-170.

The author contends that disaster-induced water problems often revolve primarily around distribution systems. Two case histories and one hypothetical water emergency are offered as examples.

In the United States, water supplies are generally available, so that surviving systems usually can be found outside a disaster-stricken area. Per capita water requirements will be much less under emergency situations than under normal conditions. Estimated requirements range from 0.5 to 5.0 gpcd for potable water supplies. Water supply efforts following the Managua earthquake targeted a provision of 1 gpcd, although much less was actually available during the peak of the emergency.

Following the 1971 San Fernando, California, earthquake, the city of 18,000 people was without water to some degree for 4-12 days. Twenty-six water trucks provided approximately 104,000 gallons of mobile-stored water to 14,000 citizens. The trucked water was chlorinated, and trucks were positioned at strategic points throughout the city for direct use by the population. There were no complaints about a lack of water, nor were health problems reported.

In 1972, a major earthquake in Managua, Nicaragua, caused severe damage to the area water system. The water distribution system sustained thousands of breaks, with water pressure dropping to zero in nearly all parts of the city. The water treatment plant was threatened but survived. The U.S. military's water supply assistance to the Nicaraguan government included an initial survey of the situation performed by a preselected and pretrained disaster assistance and survey team, and the coordination of all volunteer activities. The key to voluntary assistance in a disaster is to offer some skill or equipment that can be readily factored into the disaster response to prevent additional drains on available resources. The turnover of activities to the Nicaraguans was accomplished approximately 14 days after the earthquake, although U.S. tank trucks were left to provide water to those still lacking piped water service.

Of the 405,000 people living in Managua, 300,000 were without water following the earthquake. Of these, 200,000 people left or were evacuated, so that 100,000 people required trucked water. Forty-three tank trucks and trailers provided 37,000 gallons of water. Nearly 5,000 filled water cans were flown in from the Panama Canal Zone, although some were contaminated with petroleum products and thus discarded. Nine U.S. water purification units were used, two of which were for chlorination. Airborne, rubber storage tanks were obtained but did not prove useful. The plan was to position collapsible and portable storage tanks at strategic points throughout the city and fill them from tank trucks, although some citizens were served directly from the trucks. Three significant problems arose during implementation of the program: (1) the rubble and disarray of the city slowed delivery time; three additional deep-well watering points were established to augment the trucked supplies, (2) many trucks never reached their destination due to being drawn down by water-hungry people (establishing additional watering points and improving the distribution operation helped to resolve this problem), and (3) the facilities at the Managua water plant were not suitable for rapid filling of tanker trucks, causing lengthy delays; using the three auxiliary wells and all functioning fire hydrants near the plant helped to speed the process. Minimal water needs were met throughout the crisis without any significant incidence of waterborne disease.

The National Oceanic and Atmospheric Administration prepared an analysis of a series of simulated earthquakes occurring along the San Andreas and Hayward faults in California. In terms of water supply, the earthquake along the Hayward Fault would be the more damaging of the two. Ground shifting would rupture joining conduits and distribution lines; an earthquake measuring 8.3 on the Richter scale would severely damage the water supply system, requiring as many as six months to restore permanent service. Water systems located outside of the damage zone could provide adequate, safe water if transportation and distribution needs could be met.

The author notes that emergency water supply planning should not be overly complex, or attempt to consider all possible emergencies, and offers basic steps for utility and state core plans. The importance of periodic testing and updating of contingency plans is stressed. The federal government's responsibilities include providing assistance and guidelines and ensuring the development of adequate state emergency plans. The author concludes that the biggest water problem facing the U.S. during disaster will be the effective distribution of water rather than the provision of bulk water sources and portable treatment units.

The article is informative and well written, giving clear guidelines for emergency planning at various levels of government. The author states that particular attention should be given to the requirements and opportunities of the Safe Drinking Water Act but offers no specific information on the nature of the material.

26
Berger, Bernard B., and Albert H. Stevenson. 1955. Feasibility of Biological Warfare against Public Water Supplies. Journal of the American Water Works Association 47:101-110.

This article discusses the contamination of public water supplies by biological warfare agents and suggests measures for protection and identification.

Biological warfare (BW) is defined as the deliberate use of disease-producing microorganisms, their toxins, or the poisons produced by higher animals or plants to cause illness, death, or panic in a target population. Potential diseases in biological warfare include bacterial diseases, fungal diseases, protozoan diseases, rickettsial diseases, viral diseases, and toxins. In considering the probability of detecting BW it is likely that an act of sabotage would be suspected if an outbreak of disease is explosive, well defined geographically, and involves 20% or more of the area affected. However, if the disease agent were not normally spread by drinking water, it is likely that the outbreak would not be attributed immediately to the water supply. Public health personnel should be alert to outbreaks of nonintestinal illness that show case distribution characteristics normally associated with waterborne disease.

Factors to be considered in the selection of a BW agent for a given area include (1) the degree of immobilization desired in the target population; (2) the immune status of the population; (3) the availability of effective prevention and treatment methods; and (4) the incubation period desired. Important BW agent characteristics include (1) stability in the targeted drinking water system; (2) virulence; (3) culturability in the quantity required; (4) resistance to water treatment processes, including disinfection; and (5) resistance to detection and identification procedures.

Distribution systems may be particularly vulnerable to acts of sabotage. Generally, information on distribution system facilities and critical locations is readily obtainable by any interested party. Raw water sources may not be attractive BW targets for several reasons. The volume of the source might require too great a quantity of BW material; much of the BW agent might be wasted by flow past waterworks intakes or by biological decay in impoundments and lakes; unobserved sites for sabotage may be fewer than for distribution systems; and the treatment plant would reduce the concentration of BW agent and make detection more likely. However, standard water treatment methods cannot in all situations effectively purify water contaminated by BW agents. Viruses present a difficult problem in water treatment, although studies suggest that sufficient chlorine residuals may be effective. Standard water treatment procedures may not eliminate BW materials but will accomplish some reduction. Treatment is further complicated by the fact that a BW attack may not be accompanied by readily detectable changes in the physical characteristics of the water.

A major consideration in the feasibility of a BW attack is the quantity of material needed to produce widespread disease in the target population. This quantity must be estimated based on the human oral infective dose. Assuming one estimated human lethal oral dose in each 100 ml of 1 mil gal of water, examples of needed quantities are (1) less than 1 lb of a preparation of Salmonella anatum (and even less of S. typhosa) to produce salmonellosis in 50 percent of the exposed population; (2) less than 15 lb of dried, partially purified Staphylococcus enterotoxin to poison a majority of the exposed population; (3) less than 10 lb of partially purified Botulinum toxin to produce botulism in more than 90 percent of the exposed population; (4) 20,000 lb of potassium cyanide to poison a majority of the exposed population; and (5) 10,000 lb of sodium fluoroacetate to poison a majority of the exposed population. Significant risk and technical difficulty may be involved in the production and application of sufficient BW material to contaminate a major portion of a large city's water supply. However, the feasibility of an attack against a concentrated war-important population of around 10,000 persons would be much higher.

Recommendations for the improved protection of public drinking-water supplies against BW agents are (1) reinforcement of security measures at the source of supply, at the treatment plant, and at all critical structures in the distribution system; (2) establishment of effective liaisons between water quality laboratories and specialized bacteriological, viral, and toxicological laboratory services; (3) evaluation of the effectiveness of current water treatment processes in removing or destroying pathogenic viruses, rickettsiae, fungi, and toxins and the development of new materials, procedures, and equipment to supplement present methods; (4) strengthening of chlorination measures and continuous observation of chlorine residuals in the distribution system; (5) installation of simple, uncovered, transparent, flow-through chambers at important locations to permit observation of the physical characteristics of the water by competent persons; (6) direction of research toward the prevention of sabotage, the development of warning devices, the rapid detection and identification of BW materials, and the development of dependable methods of water decontamination; and (7) location of dependable, safe, and easily protected auxiliary sources of drinking water.

The authors provide a useful overview of the threat of biological warfare to public water systems, although much of the information may be expected to have been updated in the decades following the publication of this article.

27
Boyle, Daniel B. 1980. Interagency Connections: Insurance against Interruptions in Supply. Journal of the American Water Works Association 72:192-195.

The article assesses the benefits of establishing interagency connections to augment water systems. The author utilizes illustrative case studies.

An interagency connection is defined as "an intertie between distinct, separate water systems . . . a physical connection between the water sources operated by adjacent water agencies." Situations in which interagency connections may provide important backup sources include provision of adequate supply for fire protection; provision of temporary source of supply for the development of new communities; provision of safe drinking water if water supply sources become contaminated; improvement of the water system's Insurance Services Office rating to lower fire insurance rates for the community; and provision of interagency transfer capability to reduce construction of new transmission facilities. The California case studies used to illustrate the possibilities include a description of interagency connections in Orange County, the scheduled maintenance of Lake Mathews outlet valves, emergency water supply following flooding at Irvine Lake, water quality problems due to algae growth at the Santiago Aqueduct reservoir, and a pipeline relocation in Orange County.

The physical aspects of interagency connections are well addressed. The institutional aspects are not discussed beyond a brief observation that some water agencies may be reluctant due to fears of possible future water rights questions and allocations of capacity. The author asserts that properly structured agreements could allay these fears but does not discuss the formulation of such agreements.

28
Carns, Keith E., and Karl B. Stinson. 1982. Hazardous Material Spills--Are you Ready? Journal of the American Water Works Association 74:224-228.

The authors demonstrate the formulation of a hazardous material emergency plan by describing that of the East Bay Municipal Utility District (EBMUD) of California. The article is a review of the EBMUD plan.

To illustrate the vulnerability of water supplies to hazardous material spills, the authors reveal that a hazardous material is spilled on a highway somewhere in the San Francisco Bay area on an average of once each week. Hazards can come from spills on watersheds and in raw water storage reservoirs, in treated water distribution reservoirs, at treatment plants, and in the distribution system (contamination of the distribution system would likely come from cross-connections). Spills may originate from pipelines, railroads, motor vehicles, boats, airplanes, or fixed storage containers and may be in the form of gas, liquid, or dry solid.

EBMUD's Hazardous Material Spill Response Plan is composed of five chronological phases: (1) discovery and notification; (2) evaluation and initiation of action; (3) containment and countermeasures; (4) cleanup mitigation and disposal; and (5) documentation and cost recovery. All spill plans should contain these components. If information is needed on the nature of hazardous chemicals or on how to handle them, the Chemical Transporation Emergency Center (CHEMTREC) is contacted. CHEMTREC is a public service of the Manufacturing Chemists Association and provides immediate advice for those at the scene of emergencies. The authors note that the spiller is responsible for cleaning up a spill and may be billed for cost recovery if authorization of cost reimbursement is not obtained from appropriate state or federal agencies. Two tests of EBMUD's plan have been conducted: (1) an assumption that a truck carrying a poisonous chemical had overturned and sunk in a raw water supply reservoir near the raw water intake of a treatment plant and (2) an assumption that a pesticide spray rig mistakenly injected a pesticide into the distribution system in a residential area. The plan performed satisfactorily in both tests, although some changes were made following the exercises. The plan was also successfully used in two actual emergencies: (1) a spill of transformer oil into a navigable stream and (2) the discovery of several drums of illegally dumped chemicals that threatened to contaminate the district's largest reservoir. The authors observe that a growing number of abandoned chemicals are being discovered on watershed lands, probably due to the increasing difficulty in locating approved hazardous waste disposal sites.

The article is informative. Procedural steps in emergency plan formulation are well supported by a reproduction of the EBMUD plan. Information on testing response plans, which does not appear in all emergency plan procedural articles, completes a comprehensive treatment of the subject.

29

Byrne, Brendan, and David J. Bardin. 1976. Report on the New Jersey Water Crisis. Trenton, New Jersey: New Jersey Department of Environmental Protection.

This report describes the incident in which a combination of human error, equipment failure, and design vulnerability resulted in a ten-day loss of water service to the capital city of Trenton and adjacent townships.

Trenton and portions of Ewing, Hamilton, and Lawrence townships obtained their water from the Delaware River, their sole source of supply. Over 200,000 residents were served by the municipal system.

The crisis began on August 31, 1975, when the water filtration plant was flooded and completely disabled following cone valve failures on three high-lift pumps. Backflow through the pumps resulted in the overfilling of clear wells. By design, the clear-well overflow relief vent discharged into the pump room.

At the time of the incident the system had neither an auxiliary supply source nor any interconnection with another water system. A small reserve supply system consisting of the reservoir and five elevated tanks contained approximately three days' supply of water, given a normal consumption of 30 mgd. The reservoir level, however, could not be maintained after the high-lift pumps were disabled. Using canvas fire hose, volunteer and municipal fire companies instituted nine emergency interconnections providing 12-15 mgd although this water could not be pumped to all parts of the system. Some areas were completely without water for 72-96 hours. Emergency proclamations issued on September 2 closed virtually all businesses and severely constrained state government activities. The total monetary losses were variously estimated to be $5-$10 million. Full service to all areas was not restored until September 8. Due to structural damage, filtration capacity was limited to half that normally available until repairs were completed in March, 1976. Trenton installed permanent underground interconnections having an aggregate capacity of supplying 25 percent of the municipality's average daily water needs. Great emphasis was placed on improvement and restoration of the existing facility.

The commissioner of the state Department of Environmental Protection appointed a four-member board of experts to conduct a thorough investigation of the incident, and a six-member advisory panel to review the board's findings. The board was unable to determine the exact cause of the incident; both employee error and equipment failure were major factors. The water system had been severely underfunded and poorly maintained for years; some equipment had not been reconditioned for over 15 years. Faulty design practices, such as the venting of the clear well overflow into the pump room, also contributed significantly to the disaster. A combination of poor administrative practices, a severe lack of communication between the Water Division and the City Council, and inadequate training of utility employees resulted in the overall deterioration of the system and the disregard of emergency planning considerations. The community had resisted any increase in the costs of water service and was not aware that safe, adequate supplies could not be assured given the insufficient level of funding.

The Trenton water crisis produced a substantial increase in awareness in the state of the importance of emergency planning for water supplies and of the importance of proper investment in, and management of, community water supply systems.

30
Chambers, C. G. 1984. Protection from the Outside In. Security Management 28(4):51-60; 28(5):67-68.

This article addresses the fundamental principles of perimeter protection, including primary objectives and available measures.

The primary objectives of any perimeter protection effort are (1) to delineate a boundary, although a physical barrier for protection purposes may not necessarily follow the boundary line; (2) to control entry into, or exit from, a site through designated control points; (3) to deter potential intruders; (4) to delay the entry of intruders, detect their presence, and alert security personnel; (5) to protect site personnel from surprise attack; and (6) to demonstrate that all reasonable practical precautions have been taken to keep out innocent passersby. Constraints upon achieving these objectives include potential costs, both capital and maintenance; operational and managerial requirements; and environmental factors, including planning and/or public relations aspects. It is essential to conduct a thorough vulnerability analysis/risk assessment for each specific site. Risk assessment includes (1) assessing the characteristics of those who must operate and maintain the system as well as those who may accidentally or deliberately encounter the protection; (2) assuring the continuous, orderly operation of the site, although some changes in routine are inevitable; and (3) evaluating site usage, geography, site history, labor relations, management attitudes, local crime, political climate, public safety, and potential for theft and vandalism.

Regardless of the degree of protection required, the speed of response to a breach of protection is essential, as is the adjustment of the quality of response to the nature of the intrusion, so that major threats are not met by an inadequate response and minor threats are not met by excessive force.

The basic types of protective measures are physical barriers, alarm systems, gates, closed-circuit television, and communication and response facilities. Physical barriers may be opaque, which maintain privacy, or see-through, which allow guards and patrols the advantage of seeing out and increasing the area under surveillance. Fencing may be classified according to function: boundary fencing, barrier fencing, safety fencing, security fencing, regulatory fencing, temporary fencing, electrified fencing, and animal-proof fencing. The protection standards of existing barriers may be improved by the application of such additions as anticlimb paint, barbed wire, or barbed tape.

Presently, there are only two methods of detecting an intrusion across a perimeter: the use of static or patrol guards and the use of electronic alarms. Line-of-sight alarm systems utilize microwave transmissions; microwave "fences" are often unsuitable for the shape or topography of a given perimeter due to the need to maintain a direct line-of-sight between the transmitter and receiver. Radiating cable systems, or buried line systems, can follow variations in terrain and are invisible, making them more tamper- and accident-resistant. A new type of microwave sensor system, called a polarization radiometer detection system, combines the principles of the line-of-sight microwave fence with the terrain-following capability of the radiating cable sensor. Other perimeter alarm systems include buried line pressure sensors, which are very effective, and electrostatic field systems, which tend to have a high false alarm rate due to vulnerability to windblown debris, lightning, and vegetation movement.

Gates are an important component of perimeter protection. There should be a sequence of two gates at every entrance or exit in the perimeter of a high-risk site, and the gates should be automatically controlled to prevent simultaneous opening. Closed-circuit television (CCTV) has certain limitations; even highly trained staff cannot be expected to watch a monitor screen efficiently for more than an hour at a time, and eight or nine monitors are the most that any one person can survey. These factors make the observation of a long perimeter difficult. Human monitoring problems can be alleviated by linking cameras to the alarm system and by using video motion detection equipment. The advantages of CCTV are (1) the sight of cameras frequently acts as a deterrent; and (2) it is possible for one man to scan the entire perimeter quickly, unobtrusively, and at frequent intervals.

Communication and response capabilities are vital to effective protection systems. The rapid transmission of an alarm signal to an appropriate control center is essential, as is the preparedness of the support/response team. Detailed contingency plans should be prepared and rehearsed by response forces and on-site security personnel. Particular attention should be given to plant structures and equipment that could be damaged during a confrontation with intruders. The author notes that a response from untrained or undisciplined response forces may create more damage than the intrusion itself.

The article provides an in-depth examination of perimeter protection considerations and of various measures that may be implemented in protection plans. This information could be very useful in the development of utility security programs.

31

Channell, Elden E. 1979. Beyond the Call of Duty... Opflow 5(2):4,5,7.

This article describes the experiences of a water department superintendent in confronting two winter storm emergencies.

On January 8, 1978, an evening snowstorm resulted in the loss of power to the Amanda, Ohio, water treatment plant. By the time the situation was discovered, a power surge accompanying the restoration of power had blown a 100-amp fuse in the main panel of the plant, prolonging the power outage. All plant equipment had frozen; two portable heaters thawed the motors and waterlines, but all gauges required replacement and the entire chlorine gas system required repair. A crew from the electrical company arrived hours after the situation was reported. To avoid future delays, the electrical crew chief recommended that the utility have its account number, the number of the nearest transformer, and the name of the nearest road and its accessibility readily available when reporting an emergency.

Three weeks later, on January 25, a blizzard hit the area. By the following afternoon, the road to the water plant was completely inaccessible. Power outages had occurred in several areas, but water utility emergency crews with a four-wheel-drive vehicle were able to gain access to the plant and reported that all motors were running. During the blizzard, the plant superintendent was unable to contact the electrical utility. After the storm had passed, the general manager of the power company provided the water division superintendent with a special telephone number with which to gain access to the power company during future emergencies.

The author concludes by emphasizing the importance of emergency planning to facilitate the restoration and maintenance of water systems in emergency situations.

The article provides useful information on coordinating activities with local power utilities as part of the emergency planning process.

32

Chee, Richard. 1976. The Current State of Emergency Planning for Water Supply in the San Diego Area. Emergency Water Allocation Project, Working Paper No. 3. Irvine: University of California.

This document describes the emergency water-planning capabilities of organizations involved in the administration and operation of municipal and industrial water supplies for the City of San Diego, California.

The San Diego County Water Authority (SDCWA) is a wholesale distributor providing water to 22 local water districts; it owns no storage facilities, and water is conveyed solely by gravity flow, eliminating the need to maintain pumping facilities. SDCWA does not have an emergency water plan other than lifting rebates for agricultural customers in times of water shortage. The 22 local water districts were contacted for water system and emergency planning information. Of these, only two had emergency disaster plans; four others had emergency water quality notification plans; seven could not provide information; and nine did not respond at all.

At the county level, the Unified San Diego County Emergency Services Organization (USDCESO) has compiled emergency plans for the county, and for each city within the county, that provide a central format to be modified to suit individual locations. The plans include a planning basis, USDCESO objectives, a general emergency plan, organizational guidance, and task assignments. A list of supporting departments and agencies is also included. There are no specific plans for water emergencies. USDCESO assumes that water utilities would make most decisions during an emergency although, as already indicated, most utilities have no written emergency planning documents, thus inviting management-by-crisis committees in the event of a water disaster.

Finally, the California State Office of Emergency Services (OES) has developed a Utilities Emergency Plan that organizes emergency management teams and maintains the machinery to put them into action. The plan is activated when a state of emergency is declared by the governor. The OES does not appear to be doing any in-depth disaster planning or training for water shortages on a statewide basis.

The author provides a useful summary of emergency planning activities within the San Diego area. The reader should remember that this document addresses 1976 conditions which may have been revised in the decade that has followed.

33

Chee, Richard, and Mark E. Slafkes. 1976. A Conceptual Model of the Water Delivery System in the San Diego Area. Emergency Water Allocation Project, Working Paper No. 2. Irvine: University of California.

This report presents a model describing a regional water supply system that identifies concepts and relationships applying to normal operating modes as well as to emergency conditions. Graphic depictions of the various systems within the model are provided.

The four primary concepts expressed by the model are: (1) there is an operational system which deals directly with the movement of water from place to place to satisfy internal interests and demands as well as external natural factors; (2) there is an administrative system which processes information from other portions of the general system and communicates controls and information of an unexpected nature to these other systems; (3) there is a system (the external system) outside of the traditional view of the water system which has important impacts on the water system, and which becomes part of the general system; and (4) each system in the general system is linked with the other systems by messages, information, and controls. These communications are essential to the relationship of one system to another.

The Operational System indicates how water is gathered, stored, and delivered to customers. The elements describe sources of water, organizations distributing water, and water users. The two modes for the Operational System involve the water delivery process under normal conditions and the water delivery process under abnormal or emergency conditions. The major conceptual emphasis is on the physical process of conveying water. The actual decision-making process is represented in the Administrative System, except in states of emergency. In emergencies, other water distribution methods and controls may be introduced by the Administrative or External Systems, thus activating the second mode. The model diagram depicts sources of water, storage facilities, and the flow of water through each element.

The Administrative System is a model, developed by Henry Fagin, of the decision-making system which is concerned with policy and nonroutine matters (in this particular model, routine decisions lie within the Operational System). The model does not distinguish between decision processes found in organizations and those found in the individual. A system of organizational processes is linked to and through each other by communication links intended to inform or control the recipient of the communication. The links represent exchanges of information intended to alter the state of the system, particularly the state of the receiving organization. The model depicts the interrelationships of the many interests that are part of the water system.

The External System represents the part of the external environment which has the greatest probable impact on the particular water system. Elements within this system describe influential parameters of operation such as the generation of legal constraints, political contexts, or the amount and conditions of water imports available to the system. The External System is particularly influential in abnormal situations. The system and its relationships to other systems are dynamic. The two types of activities occurring within the External System are (1) people activities, which take place through the informal processes of the social subsystem and the formal processes of the organizational subsystem and (2) physical activities, which take place in the physical subsystem. The social subsystem includes the perception of impacts, information gathering, and subsequent actions. The organizational subsystem includes the analysis of inputs, the formulation of decisions, and subsequent actions. The physical subsystem includes changes in the state of nature and impacts on water-related geophysical systems. The various subsystems are linked to each other and to the Operational and Administrative systems by communications intending to alter the state of the recipient system. If the content or intent of messages is not recognized due to filters, breaks, incorrect timing, inadequate labeling, or some other interference, serious implications may result.

This paper facilitates an understanding of the complex, interrelated physical and institutional components of a water supply system.

34

Chiu, Arthur N. L.; Luis E. Escalante; J. Kenneth Mitchell; Dale C. Perry; Thomas A. Schroeder; and Todd Walton. 1983. Hurricane Iwa, Hawaii, November 23, 1982. Report prepared for the Committee on Natural Disasters, National Research Council. Washington, D.C.: National Academy Press.

This report describes Hurricane Iwa and reviews the impacts of the storm on Hawaiian communities.

With peak wind speeds of 73 mph, Hurricane Iwa was not the most severe storm ever to strike Hawaii, yet it resulted in record losses, making it the most costly storm in Hawaiian history. Property damage attributed to Iwa was estimated to exceed $234 million. The islands of Kauai, Oahu, and Niihau were the primary victims of the storm, with no major damages reported elsewhere. One person died and a few sustained minor injuries; the low casualty rate is attributed to an effective warning system and to the moderate intensity of the hurricane. Hurricanes generate two categories of destructive forces: (1) those of storm surge, wave action, and flooding of coastal areas, and (2) those associated with wind and rainfall. Damages to residential and commercial structures were extensive. Electrical systems sustained damages to transmission and distribution lines, resulting in extensive power outages. Power plants and substations, however, were not seriously damaged and restoration of power was generally achieved by repairing overhead lines. Overhead telephone cables, microwave antenna towers, and some commercial radio antennas were severely damaged; communications were adversely affected by power losses, as well. Transportation was affected primarily by the blockage of roads by flooding and by storm debris. Although coastal roads were damaged in some areas, inland roads sustained little damage.

Damage to the water supply system was minimal. Primary disruptions stemmed from power losses to pumps. Mobile generators furnished by the armed forces and other government agencies were brought over from the island of Oahu. Tanker trucks furnished by the fire department, the water department, and the National Guard supplied water for essential uses at various community centers where water shortages existed. There was no damage reported to wastewater treatment plants on Oahu or Kauai. Power losses caused only minor interruptions; standby power sources functioned as anticipated. Many areas had individual cesspools that sustained very little damage. Information on storm impacts was not available from the privately owned island of Niihau.

The authors offer a substantial summarization of the event and of response and recovery efforts and provide several recommendations for future hurricane disaster preparedness. Recommendations of interest to water utilities note that essential facilities should have independent backup generators that undergo regular maintenance and testing, and that facilities and procedures should be available to promptly test domestic water for contamination after a natural disaster. Sources of water that are unlikely to become contaminated should be located and cataloged.

The report is thorough and informative. The authors provide useful insights into the requirements of contingency planning for extreme wind events.

35
Clough, Ray W., and David Pirtz. 1956. Earthquake Resistance of Rock-Fill Dams. Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers 82:941.1-941.26.

This paper describes the testing of 1/150 scale physical models of rock-fill dams with earthen cores subjected simultaneously to water loadings and to simulated earthquakes generated by the shaking table. Two types of dams were compared, one having an inclined impervious core of compacted earthen materials near the upstream face and the other having a vertical core made of the same material that was centrally located. The core makes the structure water tight.

The central core dam was modeled after the Kenney Dam, about 300 feet in height, and constructed on the Nechako River in British Columbia. The model of the central core dam was similar to Mud Mountain Dam in Washington State. The maximum ground accelerations of the simulated earthquakes ranged from 0.10 g (1/10 of the acceleration of gravity) to about 1.25 g. The strongest accelerations which have been recorded during actual quakes have been less than 0.4 g.

The results showed that both designs are very resistant to earthquakes because of their flexible structure and the increased strength of the materials when subjected to dynamic loading. Even when subjected to ground accelerations exceeding the acceleration of gravity, no catastrophic slippages occurred in the models. The models suffered only minor changes of shape that would result in damages to the attached rigid structures in actual size dams. The sloping-core dam was found to be somewhat more earthquake resistant than the center-core dam because its entire structure acts as a unit and is characterized by greater rigidity that prevents to some extent the settlement which accompanies the shearing distortions. The vertical core breaks the continuity between the upstream and downsteam portions of the rock fill thus creating a zone of weakness.

36
Collins, Daniel. 1971. "Oil Spills" at Lebanon, New Hampshire. Journal of the New England Water Works Association 105:157-159.

This article describes four hazardous materials spills that affected the water supply of Lebanon, New Hampshire.

The source of water for Lebanon is Mascoma Lake in Enfield, New Hampshire. The lake water passes into Mascoma River, from which it is diverted to a raw water canal and through the water treatment plant located approximately 3.5 miles from the lake outlet.

The first spill occurred in February, 1951. A tank truck rolled over and discharged approximately 4,000 gal of kerosene into the river and intake canal. The treatment plant was in operation at the time, although no operating personnel were present. The first indication of a problem came from complaints by consumers in the vicinity of the plant. The intake was closed and steps were taken to dry feed about 70 ppm of carbon to the influent end of the sedimentation tank, which removed all taste and odor from the treated water. However, the storage reservoir and distribution system were saturated with kerosene; tank trucks filled with treated water were used to provide potable supplies during the week required to completely flush the system. A heavier-than-normal application of carbon was continued throughout the spring snow melt and runoff. At the time of the first spill, the system had no provision for feeding carbon, although a subsequent improvement of the water treatment facilities included the installation of proper chemical feed equipment.

The second spill occurred in October, 1960. A train carrying 10,000 gallons of high octane gasoline and 20,000 gal of bunker C oil derailed on the shores of Mascoma Lake. Adverse effects were reduced because the Water Department was immediately notified, the spill occurred away from the system intake, and the wind direction was away from the outlet end of the lake. The gasoline soon evaporated and posed no problem beyond that of fire hazard. Most of the oil washed up on the shoreline, so the entire spill was not carried to the treatment plant. An initial dosage of 120 ppm carbon effectively removed taste and odor and was reduced within a few days. Carbon treatment of about 20 ppm was continued over the next eight months as rainfall and wave action removed oil from the beaches and shoreline.

The third spill occurred in May, 1966, when an asphalt truck tipped over, discharging its load into a brook which feeds the Mascoma River. The asphalt rapidly solidified in the brook, causing no problems for the treatment plant. The following month, before the asphalt could be removed, the fourth spill occurred at the same site. A tank truck carrying no. 2 fuel oil rolled over at the same location and discharged its entire load over the asphalt. A combination of oil and asphalt rapidly reached the plant, although an early warning permitted the intake to be closed before the majority of the spill arrived. Operations resumed the next day with an initial dosage of 120 ppm of carbon added. This dosage was reduced within a few days but continued at a lower rate for several weeks until the raw water quality returned to normal.

This article is useful in demonstrating the importance of early warning, prompt response, and the maintenance of appropriate treatment capabilities to the successful resolution of a petroleum contamination of water supply systems.

37

Committee on the Alaska Earthquake. 1973. The Great Alaska Earthquake of 1964: Engineering. National Research Council. Washington, D.C.: National Academy of Sciences.

The Committee on the Alaska Earthquake was assembled at the request of Lyndon B. Johnson to provide a comprehensive scientific and technical account of the Alaskan earthquake and its effects. Their findings were published in an eight-volume series. Engineering is the seventh volume and consists of scientific measurement of the physical effects of the earthquake on structures and systems and an evaluation of ground motions and behavior of soils. Its objective is "to provide information that will be of use to engineers, research workers, and public officials in making earthquakes less destructive . . . [and to] aid in improving criteria for engineering design in areas where major earthquakes can be expected." The series utilizes a case study method. For the engineering panel's assessment of damage to utilities, only those utilities owned by the state or by municipalities and eligible for restoration with federal funds under Public Law 875 are considered. Privately owned utilities and other federally-owned utilities not restored with federal funds are not examined. For this study, "earthquake damage" was a term used to typify damage to be repaired that in no way indicated the exact cause of damage. For the purposes of the report, utilities are grouped by population centers.

The three principal sources of earthquake damage to Alaskan utilities were seismic action, destructive forces caused or triggered by the seismic action, and tectonic uplift and subsidence. At the time of the earthquake, the distribution system for Anchorage totaled 140 mi of line, ranging from 20- to 2-inch diameter lines buried a minimum of 10 ft. Lines were equally divided between cast iron and asbestos cement. About 8 mgd, half from the treatment plants and half from wells, were being supplied at the time of the earthquake, the normal rate of supply for the time of year (March).

The treatment plant and deep-well pumps shut down immediately due to electrical-system failures. The wood stave pipeline (elev. 252 ft) soon drained through leaks. No water was available for household use or for fire fighting. Fire hazard was, however, reduced due to failure of electrical system. The earthquake struck at 5:36 p.m. local time; the water plant resumed operation at 6:45 p.m. after the standby generator was started. The plant survived with minor damage to beams, columns, and floor slabs, but with extensive damage to a shear wall. It did not lose capacity to function. The distribution system was valved to fill usable portions and to prevent infiltration of groundwater and sewage. The damaged, but partly usable, system was made to exfiltrate for sanitary purposes and to prevent freezing. Three of the seven wells were inoperable, but the remaining four resumed operation following restoration of electrical service.

The military from Fort Richardson and Elmendorf AFB supplied truckloads of water in hardboard drums with sterile plastic liners and covers. Stations were set up to enable people to obtain water for drinking and cooking purposes. This service continued in some areas for as long as two weeks. Plans were made for a temporary water service in the form of a system of 4-in.-diameter surface-laid irrigation pipe and fittings. Lines were to be fed from fire hydrants through short lengths of fire hose, and houses were to be fed through ordinary 1/2-in.-diameter garden hose tapped from the irrigation pipe, with the garden hose fastened to the outside faucet of the house.

Sewer services were maintained though extensive emergency measures, but many unsanitary conditions existed. At the time of the earthquake, the city of Anchorage owned and maintained about 33.5 mi of storm sewers and 116.4 mi of sanitary sewers. In some areas, buried lines were completely destroyed. Photographic inspection of sewer lines proved an adequate means of locating earthquake damage.

Damage to water utilities in other affected communities was similar. In Seward, fires burned uncontrolled because no fire-fighting equipment was operational. The sewer system at Cordova sustained major passive damage from the tectonic uplift. The outfall no longer extended into tidewater at low tide, so that sewage was no longer carried away from the harbor area. In some areas, sewer outfalls were washed away by tsunami.

In all affected areas, repair and restoration efforts were scheduled to be completed before October, when freezing would again set in and hamper restoration activities.

A detailed description of earthquake damage and subsequent repair and restoration activity is given, with descriptions of the different damages resulting from different types of quake activity. The book provides an adequate overview of the engineering aspects of earthquake damage to water facilities, although only a portion of affected utilities were included in the study.

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Committee on the Alaska Earthquake. 1973. The Great Alaska Earthquake of 1964: Summary and Recommendations. National Research Council. Washington, D.C.: National Academy of Sciences.

The Committee on the Alaska Earthquake was assembled at the request of Lyndon B. Johnson to provide a comprehensive scientific and technical account of the Alaskan earthquake and its effects. Their findings were published in an eight-volume series. Summary and Recommendations is the eighth volume and contains the summaries, conclusions, and recommendations on earthquake loss-reduction measures formulated by each of the committee's seven specialized panels (biology, engineering, geography/human ecology, geology, hydrology, oceanography, and seismology). The series utilizes a case study method involving scientific measurement of the physical effects of the earthquake and assessment of sociological impacts through analytical studies and direct reporting.

An assessment of the earthquake's impact on area water supplies was conducted by the panel on engineering. A special emphasis was placed upon the earthquake resistance of dams, with the observation that "the failure of a dam can be such an enormous catastrophe that special efforts to increase dam safety are essential." The panel noted the urgent need for the development of reliable methods for evaluating the earthquake resistance of old earth dams and stated that hazardous dams should be brought to modern standards of safety, or their use should be restricted. The panel further concluded that research should be initiated to develop more reliable methods of earthquake design of new earth dams, an important part of which would be the placing of strong-motion accelerographs and other suitable instruments on dams and in their vicinity to record earthquake motions. The engineering recommendations included the statement that the utility departments of cities in the seismic areas of the country should evaluate the earthquake resistance of essential utility systems and modify them as needed to provide adequate earthquake resistance, with examples given of shut-off mechanisms in gas distribution systems and the maintenance of an auxiliary water supply system.

The usefulness of the Summary and Recommendations volume is restricted by the very brief overviews of each panel's findings and by the vague, overgeneralized nature of the ensuing recommendations. For example, the engineering volume contains an extensive assessment of damage to water supply systems, yet the only recommendations pertaining to water supply given in this volume are the observations that utilities should evaluate their systems and modify them as needed, and that an auxiliary water supply system is useful. Such recommendations could have been made without an in-depth examination of the effects of an earthquake. Given the extent of the evaluation of the earthquake's impacts on the water supply and water treatment systems, more specific recommendations could have been made regarding earthquake resistent design of water systems, damage estimation and repair of water systems, alternative sources of water supply, and postdisaster interactions with utility customers.

39

Conway, John B. and James D. Lucas. 1977. The Environmentalist's Role in a Major Emergency or Disaster. Journal of Environmental Health 40(1):46-51.

The authors' objectives are to provide insights into possible environmental health problems encountered in disaster situations and to offer recommendations for future experiences. Emergency planning in Ohio and Washington states is reviewed, and a case history from Ohio is given as an illustrative example.

The exact sequence of the mobilization of local and state emergency personnel varies from state to state and with the magnitude of the event. In Ohio, each county has a director of disaster services to coordinate local agencies and work with the state disaster service agency. The Ohio Disaster Service Agency has the basic legal responsiblity for disaster emergencies and for developing a statewide plan which reflects the role of other relevant agencies. The Emergency Environmental Health Action Plan is designed to provide a safe potable drinking water supply; a satisfactory means for disposing of liquid wastes; an effective method for the removal and disposal of dead animals and humans, a control effort regarding rodents and vectors of disease; a wholesome and bacteriologically safe food supply; a procedure for cleaning up damaged houses and public buildings and those used as temporary shelters or housing facilities; and a method for disposing of and reclaiming household materials and stored food products. The authors list a series of eleven steps, developed by the Ohio Department of Health, to be implemented following a disaster situation. Specific to water supply and treatment are: (Step 3) Contact local government officials and obtain information as to where public services are still available and where they are disrupted. If possible, contact the Ohio Environmental Protection Agency for assistance in public and municipal water and sewage supplies. (Step 4) Contact and inform the public, through mass news media or handouts, of the procedures to be followed to obtain safe potable drinking water either by designating sources of potable water or by giving out information about the emergency disinfection of private water supplies by chemicals or by boiling for 5-10 minutes. (Step 5) In areas without sewage disposal services, provide advice and assistance in the location and construction of leaching earthen pit privies or slit trenches or inform the people affected where operable public sewage disposal facilities are located for their sector of the community. Specific recommendations regarding the emergency provision of water and sewage services are given with the procedural steps.

In Washington State, each county has a department of emergency services. Their major duties include providing backup in civil defense emergencies, search and rescue operations, and disaster relief; maintaining communications services; coordinating the efforts of local governmental agencies, state and federal agencies, and relief agencies; mobilizing trained volunteer workers for emergency mass feeding; radiological monitoring; coordinating first aid and medical care; and shelter management. The complete sequence of emergency service responsibility for the state is described. No information is given regarding emergency water supply or treatment.

On April 3, 1974, the town of Xenia, Ohio, was demolished by a tornado that was perhaps the largest ever seen on earth. Winds within the funnel reached 318 miles per hour, and the storm traveled through the town at speeds up to 48 miles per hour. The tornado's path was a half mile wide; 2,000 homes and small businesses were damaged or destroyed. Thirty-three people died and 1,778 were left injured or ill. The total damage was estimated to exceed $100 million. Within hours of the tornado's passing, the sheriff's office and the local radio station issued notices to avoid drinking from the Xenia public water supply until further notice. The following day, nearby Montgomery County industries began providing bottled drinking water, food, medical supplies, and portable toilet facilities. Large quantities of drinking water came from area dairy and bottling plants. On April 5, the Xenia public water supply was sampled to determine its safety for human consumption; meanwhile, information was distributed describing how to treat the water temporarily for drinking purposes. Bottled drinking water was available on a 24-hour basis at the health department. On April 6, lab tests confirmed the safety of the water supply inside Xenia city limits. An adjacent area, also on the Xenia public water system, was not sampled for a week due to a loss of pressure in the system; it was declared safe on April 15. Due to the extent of the destruction, appropriate landfill sites became a high priority. All sites had to be approved by the local health department, particulary regarding the adequacy of cover and the potential effect on groundwater supplies. An estimated 1 million cubic yards of tornado debris were buried in the landfill sites. Postdisaster environmental health equipment included chlorine test kits and cross-connection test kits.

A postdisaster environmental program was established to provide food protection, trailer park and mobile home sanitation, public water supply surveillance, school sanitation, vector control, private water supply control, home and public building hygiene and maintenance, sanitary monitoring of designated disaster assistance centers, health education, and the development and implementation of a coordinated emergency preparedness plan. The authors recommend that each health department formulate its own emergency plan in cooperation with local agencies; that each department having five or more environmental health specialists designate one as disaster personnel to travel to disaster sites and assist until additional environmental health personnel can be hired; and that some type of "open budget" fund be established for the acquisition of appropriate equipment for a given emergency to avoid delays in postdisaster responses.

The article contains clear, comprehensive information on the environmental health aspects of disaster preparedness.

40

Cotruvo, Joseph A. 1981. EPA Policies to Protect the Health of Consumers of Drinking Water in the United States. Science of the Total Environment 18:345-355.

This article provides a general overview of the activities and policies of the Environmental Protection Agency's Office of Drinking Water in executing the mandates of the Safe Water Drinking Act of 1974.

Legislative efforts to control the contamination of drinking water are aimed at all points of the water service system, including source protection, water treatment controls, and distribution system controls. A brief description of past, current, and future regulatory actions and guidelines is given, including the Safe Drinking Water Act, the National Interim Primary Drinking Water Regulations, and the National Secondary Drinking Water Regulations. Maximum Contaminant Levels (MCLs) are established for drinking water by the EPA to control organic and nonorganic chemical contamination. Emergency response actions to contamination by nonregulated chemicals and by highly toxic spills are based on an emergency advisory program developed by the Criteria and Standards Division that produces documents known as SNARLs (Suggested No Adverse Response Level). These reports are intended to provide guidance to local and state organizations in determining potability. Water contaminant levels with negligible risk at various exposure conditions are calculated for specific chemicals.

No other emergency response or emergency planning activities are mentioned in this paper.

The paper provides a thorough overview of the structure and implementation of the Safe Water Drinking Act of 1974.

41
Craft, T. F. 1970. Planning for Water Quality Emergencies. Journal of the American Water Works Association 62:181-184.

The author addresses possible water quality emergencies and recommends appropriate planning measures.

In addition to expected fluctuations in water quality, such as changes in turbidity, there exists the possibility of acute deterioration due to an abnormal event upstream, such as a hazardous materials spill, which will require an immediate, nonroutine response. The first step in planning for water quality emergencies is to determine the nature and location of potential sources of contamination within a watershed. Treated and untreated domestic, municipal, and industrial effluents may be discharged in unacceptable concentrations, and all methods of chemical storage and transportation pose the threat of accidental discharge. The second step is to minimize vulnerability as revealed by the watershed survey through planning or through physical adjustments. If the threat of contamination cannot be eliminated, it is necessary to maintain elements commonly required for response, such as chlorine, carbon, clay, and auxiliary water supplies. Temporary baffles around the raw water intake can be valuable in diverting pollutants that are confined to the water surface. The third step is to monitor water quality and employ measures to recognize emergencies as quickly as possible to maximize the effectiveness of planned emergency response activities.

Practical recommendations are given to assist water system managers in mitigating water quality emergencies.

42
Cropper. M. L. 1976. Regulating Activities with Catastrophic Environmental Effects. Journal of Environmental Economics and Management 3:1-15.

In this paper the author analyzes two types of catastrophes. The catastrophe is defined as an unforeseen event which reduces society's level of consumption (or utility) to zero. The first type of catastrophe characterizes certain types of pollution problems such as radioactive pollution produced by a nuclear power plant or the pollution of the stratosphere by aerosols or by supersonic aircraft. This type of catastrophe is expected to result in a temporary reduction in utility if the threshold level of pollution is reached, e.g., some uncertain threshold concentration of radionuclides will cause death or severe mutilation. The crossing of this pollution level is referred to by the author as a catastrophe because of the drastic losses to society which it entails and because of the suddenness with which is must occur.

The second type of catastrophe describes an irreversible depletion of a nonrenewable resource for which no substitute is available and which may have catastrophic effects on the environment. Relative permanence is an important distinction between the two types of catastrophe. Catastrophic pollution problems may be reversible, since it may be possible to reduce the size of the pollution stock. In the depletion case the catastrophe is irreversible if the amount of nonrenewable resource which is extracted exceeds available reserves and the consumption of the resource becomes zero.

Using a vigorous mathematical approach the author analyzed two problems involving catastrophe: (1) the steady-state equilibria and approach paths for pollution when the effects of pollution are catastrophic; and (2) the optimal rate of extraction of a nonrenewable resource when available reserves are uncertain. These problems possess solutions which differ significantly from standard resource allocation problems in which catastrophic effects are absent. The major conclusions stemming from these analyses are (1) when the effects of pollution are potentially catastrophic, the unique, stable equilibrium solution may not be obtained and multiple equilibria, as well as a nonequilibrium solution, are possible; (2) when available reserves of an exhaustible resource are considered certain society will deplete the resource over an infinite horizon with the amount extracted declining continuously to zero with time; and (3) when reserves are uncertain, the path of planned extraction may not be monotonic and may even increase over time, in which case future generations will be worse off, since society will always use up any finite amount of the resource faster under uncertainty than under certainty.

43

Crusberg, Theodore C., and David L. Smith. 1982. Analyzing Transportation-Related Hazardous Material Spills in New England. Journal of the American Water Works Association 74:498-505.

This study attempts to quantify the incidence and severity of transportation-related discharges of hazardous materials into surface waters in New England. The states included in the study area are Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island. The report files of the U.S. Environmental Protection Agency Region I were examined for this analysis along with data obtained from the Connecticut Department of Environmental Protection.

The Water Pollution Control Act of 1970 required the reporting of spills of oil and hazardous materials to the federal government. The National Response Center (NRC) was established in 1973 to record spills and provide federal expertise to assist in spill cleanup. Several agencies maintain and monitor hazardous materials spill reports, yet levels of reporting fluctuate and many spills may go unreported. During the 1970's, the New England area suffered several transportation-related hazardous materials accidents resulting in the entrance of contaminants into surface water supply sources.

Data on spill reports for the period 1972-1981 were obtained from USEPA Region I. Data on the number and types of spills occurring in each New England state before 1978 were incomplete or unavailable; therefore, the period 1978-1981 constitutes the primary study period. The state of Connecticut maintains an aggressive surveillance program and their spill report data were more comprehensive than those of federal agencies. The authors compared the USEPA reports to those listed by the Connecticut Department of Environmental Protection (CDEP) for the same period to obtain an estimate of possible underreporting of spills to the USEPA. Assuming that the efficiency of reporting hazardous material spills to the USEPA was the same for each New England state, an estimated spills parameter was computed for the entire study area. The data from Connecticut indicated that 95 percent of all spills were not reported to the EPA and that 77 percent of the transportation-related spills that entered surface waters went unreported.

The study revealed that almost half of all reported transportation-related spills had a direct impact on a surface water body and that approximately 30 percent of all spills were associated with the transport of hazardous materials. The proportion of transportation-related spills in which some quantity of oil or chemical entered the water ranged from 35 percent for New Hampshire to 59 percent for Rhode Island. Connecticut and Massachusetts accounted for 71 percent of all hazardous material spills. Seasonal variation might be expected to influence the incidence of hazardous materials spills due to hazardous weather conditions and increases in the volume of fuel oils transported. An analysis of study area data revealed that 37.5 percent of all transportation-related spills occurred during the months of January to March.

The article underscores both the difficulties of maintaining comprehensive hazardous material spills monitoring programs and the importance of reporting spills to water quality managers.

44
Cunningham, Atlee M. 1973. Joint Discussion--Utility Emergency Planning Pays Off: Hurricane Procedures in Corpus Christi, Texas. Journal of the American Water Works Association 65:474-477.

The author describes the Corpus Christi Water Division's contingency plan, which was designed to facilitate operations during hurricanes and other disasters, and which clearly details employee assignments. An account of contingency plan implementation during Hurricane Celia is given.

The Corpus Christi plan emphasizes response to hurricane hazards. Hurricane damages result from extreme rainfall conditions (e.g., 36 inches in three days), excessive wind velocities, and storm tides. The plan clearly describes employee duties. Crew units are stationed at the reservoir, the water-filtration plants, the in-town pumping station, and the distribution office, which serves as the emergency operations headquarters. Communications are maintained through telephones and shortwave radio. Each station contains radio equipment with auxiliary power. Upon the declaration of "Condition III," all emergency personnel are alerted to secure their families and report for duty. Hurricane preparations include fueling pumps and vehicles; clearing the area of loose objects; checking and stockpiling shoring lumber; and waterproofing sheeting, tools, nails, ropes, and other items. The advent of "Condition II" requires all superintendents and supervisors to report to stations and conduct progress checks of all emergency activities. The declaration of "Condition I" means that a hurricane is approaching landfall. A 24-hour routine operation with fully manned emergency stations begins.

The manning of the stations is planned to include personal property surveillance. Immediately after the hurricane passes, certain personnel are assigned to clear debris and repair damage, while others are sent home to assess damages and assist their families. When the group sent home returns, the on-job employees are sent to check their own homes. Employees have stronger performance records when given the opportunity to retain contact with their homes.

On the morning of August 3, 1979, Condition II was declared when Hurricane Celia, with a wind velocity of 115 mph, was 95 miles east of Corpus Christi. Condition I began at 1:00 p.m. that afternoon, with the hurricane reaching the barrier islands east of the city at 4:15 p.m. Wind velocities reached an unexpected 161 mph, resulting in massive destruction of buildings and other structures. All water sytstem components had lost telephone and electrical services by 5:20 p.m. One filter plant initiated auxiliary power at 4:00 p.m., with water production resuming at reduced pressure levels approximately five hours later. Emergency crews worked through the night, with full water pressure being restored within 24 hours. One treatment plant regained power eight hours after the failure; restoration of in-town pump station power required one-and-a-half to seven days.

Windows and doors in the water plants were blown away, necessitating the wrapping of large motors and switchgears in polyethylene sheeting. Flying glass, sheet metal, and lumber presented the greatest hazard to employees. Approximately 280 refugees were sheltered in the two treatment plants. Communications were conducted via two-way radio. All overhead water tanks emptied when pumping failed, and large fire-line connections and domestic services were broken. The tanks, designed to withstand 150-mph winds, survived the hurricane. Two steel ground-storage tanks suffered severe roof damage. Waves and wind tides generated discharges over the dam at Lake Corpus Christi, resulting in a 29-ft flood crest downstream. The dam sustained damage to bar screens at the outlet works and severe damage to the stone-earthwork protection. There were extensive private property losses around the lake.

Adverse economic impacts included utility replacement and repair costs, loss of revenue from customers with damaged services, and reductions in water-division financing due to the damage sustained by all facets of the community.

The article presents an informative account of a water utility's response to hurricane conditions.

45
Davies, Sherwood, and John C. Bumstead. 1982. Nuclear Power Reactor Accidents and the Role of Water System Managers. <u>Journal of the American Water Works Association</u> 74:383-390.

This article discusses the impacts of accidental atmospheric releases from a nuclear power reactor and essential preparatory measures for water systems. Information provided includes radioactivity terminology, policy decisions for water system managers, and facts needed by managers in the event of an accidental release.

Radioactive substances released into the environment from a nuclear power reactor core may include radioiodines, radioactive particulates, and inert radioactive gases. All are potential sources of population exposure although inert gases do not react chemically and are dispersed without leaving residue on land or water. The rate of deposition of radioiodines and radioactive particulates depends on concentrations in the plume, wind velocity, plume depletion, and plume washing by rain or snowfall. Once deposited, the behavior of nuclides in a body of water is influenced by minerals and chemicals in the water. High concentrations of minerals and organics would tend to reduce radioactivity by adsorption and reaction; in clear, clean water, radioactive substances may occur in higher concentrations. Thermal stratification in large reservoirs and lakes would affect dispersion and dilution; a multilevel raw water intake would allow the withdrawal of least-contaminated water. Radioactivity deposited on snow-covered watersheds could be transported to a reservoir during a period of thaw. Seven radionuclides produced by a reactor have been identified as having the greatest potential for significant internal doses from ingestion: iodine 131, iodine 133, strontium 89, strontium 90, cesium 134, cesium 136, and cesium 137.

Federal agencies have proposed two emergency planning zones around a nuclear reactor: (1) plume exposure pathway zone--whole body external exposure to gamma radiation from the plume and deposited materials, and inhalation from the plume (radius 16.1 km/10 mi) and (2) ingestion exposure pathway zone--ingestion of contaminated water or foods (radius 80.5 km/50 mi). Following a release, the time available to implement protective measures for ingestion pathways is greater than the time to implement protective measures for plume pathway exposure. The time between occurrence of an accident and the radioactive release may range from 30 minutes to several hours; the period of release may range from 30 minutes to several days. Immediate protective action for a large release would be sheltering and/or evacuation of the downwind population. A smaller release might not require sheltering or evacuation, but water and food contamination could still result. Measures to restrict ingestion of contaminated water include prohibition of consumption of public drinking water and substitution of bottled water or soft drinks; use of water from hot water tanks filled prior to contamination; and use of water from domestic zeolite softening processes. Treatment processes for removal of radioactivity from municipal water would entail modifying chemical dosages (e.g., carbon and lime), according to radiological analyses. Tritium would not be removed, while radioiodine and alkaline earths would be significantly reduced.

A detailed discussion is given of current federal regulations and guidelines concerning external and internal exposures. There is little guidance in establishing exposure limits for drinking water. The U.S. Federal Radiation Council (FRC) developed protection action guides (PAGs), defined as a plan for action when a projected absorbed dose of radiation by individuals in the general population warrants protective action after a contaminating event. However, no PAG specifically addressed drinking water. The U.S. Environmental Protection Agency (USEPA) has assumed statutory responsibilities from the FRC but has not formulated a consistent approach to setting drinking water exposure limits. The authors recommend that a PAG for drinking water be established and offer specific suggestions for determining appropriate exposure limits.

This article discusses virtually all aspects of the impacts on water supply of an accidental radioactive releases from nuclear reactors. Substantial information is presented clearly and concisely and provides a thorough introduction to water system emergency planning for radioactive release hazards.

46

Department of the Army, U.S. Army Corps of Engineers. 1983. Emergency Employment of Army and Other Resources: Natural Disaster Procedures. Engineer Regulations 500-1-1.

This regulation prescribes administrative policies, guidance, and operating procedures for natural disaster activities of the U.S. Army Corps of Engineers (USACE) and their work for the Federal Management Agency (FEMA).

USACE natural disaster activities are mandated by the Flood and Coastal Storm Emergencies Act (PL84-99) and by the Disaster Relief and Assistance Act of 1974 (PL93-288). PL84-99 authorizes Corps of Engineers activities in disaster preparedness; advance measures; flood fighting and rescue work; rehabilitation of flood control works damaged or destroyed by a flood; protection or repair of federally authorized shore protection works threatened or damaged by a coastal storm; provision of emergency drinking water; and drought assistance.

PL93-288 authorizes FEMA to coordinate the activities of federal agencies in providing disaster assistance and to direct five agencies (to include the Corps of Engineers) to utilize available personnel, supplies, facilities, and other resources in providing such assistance in the event of a major disaster or emergency declaration. This regulation is used as the basis for natural disaster procedures by all echelons of the Corps of Engineers.

Specifically, chapter 6 of this document describes emergency water supplies and drought assistance provisions of PL84-99, as amended. The Chief of Engineers can provide emergency supplies of clear drinking water, on such terms as he determines to be advisable, to any locality which he finds is confronted with a source of contaminated drinking water causing or likely to cause a substantial threat to the public health and welfare of the inhabitants of the locality. Chapter 9 provides instructions for Corps of Engineer agencies for rendering assistance to FEMA.

This document provides a thorough introduction to the regulatory basis for USACE natural disaster response capabilities.

47

Drabek, Thomas E. 1984. Some Emerging Issues in Emergency Management. National Emergency Training Center Monograph Series. Washington, D.C.: Federal Emergency Management Agency.

This monograph examines rising policy issues in emergency management and their relationship to present and future national policy. Nine policy issues are analyzed within a temporal framework. Examples of water-related hazards are cited to support the rationale for the proposed framework.

The author offers a general framework for analyzing four major disaster phases: preparedness, response, recovery, and mitigation. Each major phase is then subdivided into two specific subprocesses to produce eight distinct categories, respectively: (1) planning; (2) warning; (3) mobilization/evacuation; (4) emergency response; (5) restoration; (6) reconstruction; (7) hazard perceptions; and (8) adjustments (structural and nonstructural). These eight categories provide the temporal framework for policy analysis from a national perspective.

The issues addressed are (1) the absence of an integrated disaster-loss data base; (2) training and certification of emergency management professionals; (3) funding for integrated community warning systems; (4) legal issues at the state and local levels; (5) Good Samaritan legislation; (6) mental health needs of first responders; (7) postevent mitigation efforts; (8) nuclear war as a planning problem; and (9) all-hazard insurance. Each of these emerging issues is presented with consideration given to differing levels of abstraction and time horizons.

Six shifting national trends are offered and discussed, assuming that they will have some future impact on emergency management. These trends include a shift from federal focus to state and local governments and from structural to nonstructural mitigation strategies. Shifts appear also in population movements, in definitions of casualty and negligence in liability cases, and in the emergence of a new, revitalized professionalism in the emergency management field. Finally, the manner in which the shift to multi- or integrated hazard management will be implemented in the next decade can affect citizens at risk in hazard areas and the nation's security.

This monograph provides a well-structured and comprehensive reference for examining potential policy issues pertinent to emergency water planning.

48

Epstein, Joseph. 1974. Properties of GB in Water. Journal of the American Water Works Association 66:31-37.

The purpose of this article is to summarize the practical methods of detecting and minimizing the contamination of water supplies with the nerve gas isopropyl methylphosphonofluoridate, commonly referred to as GB or Sarin. The feasibility of contamination of water sources with GB levels likely to be injurious to the consumers is also examined.

GB dissolves rapidly in water and has solubility of at least 50 percent; however, the toxicity of aqueous solution of GB is reduced. Maximum permissible concentration in water used by civilian populations is set at 0.004 ppm with the daily intake not greater than 0.01 mg (at the consumption of 2.5 l of water per day). A level ten times the tolerance concentration would be needed to produce moderate signs of intoxication in a small fraction of the population. The author estimates that in order to contaminate Boston's 415-billion gallon Quabin Reservoir to a uniform level of 0.004 ppm, it would require over 10,000 lb of GB. To render water dangerous for drinking would require 100,000 lb of GB; this amount is logistically unfeasible and far too large for safe handling by a saboteur. This suggests that the GB contamination is possible only in small bodies of water with capacity not exceeding one million gallons.

Should the water supply become contaminated with GB, its presence can be easily detected and treatment procedures to remove or destroy the compound are available. The most effective treatment methods include (1) treatment with chlorine to accelerate the rate of hydrolysis of GB into the anions of isopropyl methylphosphonic and hydrofluoric acids; (2) raising pH with soda ash, slaked lime, or magnesuim hydroxide to approximately 10 to allow the GB to hydrolize; (3) catalytic hydrolyzis with strongly basic ion exchanges; or, (4) absorption on activated carbon. Boiling contaminated water for a period of 20 minutes would reduce the GB concentration to 1/1,000 original; however, the vapors above the boiled liquid should be contained or exhausted to the outside air.

49

Erickson, Claude R. 1963. Water Utility Planning for Nuclear Attack. Journal of the American Water Works Association 55:1237-1248.

The author discusses the effects of nuclear weapons, postattack conditions, water utility vulnerability assessment, and nuclear disaster planning.

Most material damages will come from the blast, shock wave, and fires following a nuclear explosion. Another product, thermal radiation, produces intense heat and light that can ignite fires and cause skin burns and eye injuries. Nuclear explosions also produce large quantities of unstable radioactive elements. Radioactivity produced by the burst may be divided into initial radiation, which lasts for up to one minute and comprises approximately 5 percent of the total energy of the burst, and residual radiation, which lasts for more than one minute, comprises approximately 10 percent of the total energy of the burst, and is responsible for radioactive fallout. Most fallout is carried in water as insoluble matter; the author indicates that up to 90 percent can be removed from water supplies by filtration. During postattack conditions, familiarity with emergency sources of water, power, and communications will be essential. Each utility should establish a succession of command, liaisons with other utilities and civil defense agencies, and auxiliary communication facilities. During the repair and restoration period radiation dosage records should be maintained for all personnel, and personnel movements should be restricted according to established exposure limits.

When conducting a vulnerability assessment, water utilities should include all items directly or indirectly affecting their operation. Items include fallout shelter protection for (1) the operators, (2) the raw water source, (3) the treatment processes, (4) the treated-water storage, (5) the structures, (6) the power supply, (7) the chemical storage, and (8) the distribution system. Coordination between all area facilities is essential to maximize available resources. Disaster planning should consider critical components and services revealed during vulnerability analysis and prepare to minimize physical damages and postattack disruption. Those utilities which are able to restore some degree of service will be crucial to recovery and survival efforts.

50

Fagin, H.; T. Edwards; and R. Schinzinger. 1977. Emergency Water Allocation: Achieving Equitable and Effective Water Allocation. Emergency Water Allocation Project, Working Paper No. 8. Irvine: University of California.

This is the second in a series of four papers describing a project that assisted water districts in San Diego County, California, in the formulation of water allocation and system restoration procedures to prepare for sudden emergencies. This paper discusses alternative measures for the allocation of water in emergencies.

Customers are affected by water emergencies along the dimensions of quality and quantity of water. Within these two dimensions five possible supply conditions exist and are listed with the appropriate response mechanisms: (1) enough potable water (normal delivery); (2) some potable water (ration); (3) no potable water (deliver by truck); (4) enough nonpotable water (warn); and (5) some nonpotable water (ration and warn). The normal allocation of water occurs through demand-initiated deliveries of water of standard quality flowing through the regular distribution system. Three of the response mechanisms represent alternatives to normal allocation and delivery in emergency situations: (1) delivery by truck, (2) rationing of water, and (3) warnings regarding water quality.

Trucked water delivery must be instituted when the physical system is inoperative or the supply is severely contaminated. One type of delivery uses trucks with permanently attached water tanks and the driver is responsible for controlling withdrawals from the tank. A second type uses trucks which pull detachable water tank trailers. The trailers may be positioned and left unattended so that the consumers withdraw their own supplies. The absolute quantity used may be limited by controlling the timing of periodic water replenishment in an unattended tank. A more equitable distribution might be obtained if the driver remains in attendance.

Rationing of water supplies may be accomplished through several methods. A request for voluntary reductions in water use is usually the least effective program. Fixed quantity allocation, a compulsory program, involves the distribution of a fixed quantity of water to each residential customer. Determining an equitable allocation is difficult without sufficient knowledge of the number of persons per household. Percentage reduction, a second type of compulsory program, requires that allocations be determined by applying a set percentage against the equivalent month's use from the previous year. Percentage reduction rewards excessive water use while penalizing those who have reduced water use in the past. The three methods described here share the advantange of allowing the consumer to decide which uses will be reduced, although the compulsory programs are generally more effective than voluntary conservation efforts.

Regulations limiting use discretion are primarily directed toward limiting outdoor water uses due to the difficulties in enforcing indoor use restrictions. Restrictions usually take the form of outdoor watering schedules, prohibitions against water waste, and prohibition of all outdoor uses. These approaches are based on the assumption that social pressure will effectively ensure compliance, although resentment over the loss of personal freedoms may reduce customers' willingness to comply. Penalties imposed to increase compliance may take the form of warnings, fines, citations, flow restricting devices, service shutoff, or pricing. The effectiveness of penalties may be related to enforcement practices.

Incentives to conserve water usually consist of the distribution of water conservations kits, although some use has been made of programs that apply a customer's water savings in one period to usage in the next period so that past savings can offset any use exceeding the allocation. Conservation coupons which could be redeemed for water, cash, or merchandise are generally infeasible due to the attendant costs.

Three mechanisms exist by which utilities may restrict the supply of water available to customers by manipulating the physical system: (1) pressure reduction, (2) intermittent shutoff, and (3) complete shutoff. Both pressure reduction and intermittent shutoff pose the risk of damages to the system resulting from negative pressures. Complete shutoff may be required if an emergency results in extensive damages to the water system.

In the event of a water quality emergency, all customers must be warned that supplies may not be potable. Notification should proceed through multiple warning mediums to maximize the number of consumers reached. The content of the warnings should include clear instructions for appropriate behavior. If conventional warning methods are not possible, alternatives such as coloring the water or creating distasteful odors may alert users to a potential problem.

The sequencing of demand reduction measures is important. Programs frequently begin with the least restrictive measure in a desire to avoid inconveniencing customers more than is necessary. However, implementation of the most severe restrictions first underscores the seriousness of the emergency and may produce some reserve supply. The impact of usage reduction on water system finances can be severe if insufficient revenues result. The systematic dissemination of information is a third important issue in implementing a conservation program. Information programs seldom motivate consumers to save water but can be useful once the decision to conserve is made.

This publication is valuable in its inclusion of demand management techniques in the emergency planning process. However, the study focuses on drought conditions rather than acute water emergencies.

51

Fagin, H.; T. Edwards; and R. Schinzinger. 1977. Emergency Water Allocation: Improving Emergency Preparedness. Emergency Water Allocation Project, Working Paper No. 10. Irvine: University of California.

This is the last in a series of four papers describing a project that assisted water districts in San Diego County, California, in the formulation of water allocation and system restoration procedures to prepare for sudden emergencies. This paper discusses common causes of failure in organized response to disaster and presents preparedness activities designed to reduce the potential for failures in the emergency response system.

Potentially dysfunctional components of emergency response systems include (1) communications failures--caused by physical damage, system overload, or message flow impedance; (2) convergence behaviors--the influx of persons, supplies, and messages on the disaster impact area; and (3) coordination--among water agencies and of water agencies with other emergency response entities.

Misconceptions about individual behavior during emergencies can impede emergency planning by diverting scarce resources from direct restoration activities. It is commonly believed that social disintegration follows disaster, yet disasters often strengthen communities by increasing altruistic behaviors and minimizing conflicts as a communal emergency consensus develops. A second common myth is that looting frequently occurs in times of crisis. However, seizures of personal property are usually effected by the community to serve the common good and not by individuals. A third myth involves the concept of withdrawal. Officials often hesitate to issue preimpact warnings because of the belief that panic will ensue; however, research has indicated that panic is not usually present in emergency response. Another aspect of the withdrawal myth is the image of a helpless, completely dependent population following a disaster, which results in the creation of elaborate aftercare preparations. Disaster victims frequently make private arrangements following the impact, and resources employed to provide extensive emergency shelter programs might be better used elsewhere.

The expenditure of time and other resources required for emergency response activities may adversely affect the adoption of planning measures. Implementation is often improved when the measures entail activities that provide immediate payoffs by enhancing normal operations. The authors note that emergency preparedness is necessarily tied to readiness for certain specific types of events; it is impossible to prepare for all possible emergencies. For this reason, the maintenance of flexibility and ingenuity in response planning improves its potential effectiveness.

52

Farmer, Edward. 1958. Alternative Sources of Power for Water Utility Pumping Stations. Journal of the American Water Works Association 50:1297-1305.

The author discusses the reliability of pumping stations operated by electric power and the provision of alternative, emergency sources.

Reliability is difficult to define and varies from one system to another. True reliability would be such that service could be maintained during all demand periods under any imaginable condition. Although true reliability cannot be attained, utilities should strive to maintain near-normal or minimum service during any emergency that might arise, even infrequently, from conditions that might conceivably be encountered within a given system. Assuming that water is available, that the station has adequate pumping capacity, and that the transmission and distribution mains can deliver water to all users in the quantities required, the reliability of service is dependent on two factors: (1) the on-site and internal electrical facilities and (2) the power supply to the station site. In well-designed systems, power disruptions arising from internal or on-site disturbances usually will be partial or momentary.

The primary consideration in planning alternative sources of power is the reliability of the power lines and of related facilities between the power generators and the pumping stations. The degree of the hazard, the probable duration and consequences of power outages, the effects of pressure reductions or water outages of varying duration, the cost of duplicating or supplementing the electric power source, the possibility and desirability of looped transmission mains from other stations, and the effect or desirability of elevated storage should all be evaluated. Where multiple electric services are not available and for small water systems, gasoline, diesel, or dual-fuel engines directly connected to pumps or to electric generators are practical sources of standby power. In large, principal stations multiple feeders can provide protection at much lower costs than standby equipment.

The article provides useful information with which to plan and evaluate auxiliary power sources for water systems.

53

Federal Emergency Management Agency. 1983. Integrated Emergency Management System: Hazards Analysis for Emergency Management System (Interim Guidance). Washington, D.C.: Federal Emergency Management Agency.

This document presents a general approach to hazards analysis, definitions, processes, and models. The purpose of the guide is to provide federal, state, and local officials with a common framework for hazards analysis. Hazards analysis activities and sample worksheets are provided.

Hazards analysis is a process for determining the emergency management needs of a community; it involves knowledge of the hazards to which the community is subjected and knowledge of the community. Knowledge of the hazard includes determinations of probability, intensity, and location made on the basis of historical evidence, empirical research, or community perception. Hazards range from high-probability, low-impact events to low-probability, high-impact events. Some hazards may be characterized by available historical and quantitative data, while others must be estimated through assumptions of location, intensity, and probability. Knowledge of the community involves an inventory of the areas and resources of the community susceptible to damage and an assessment of the loss that would result from the occurrence of an event at a given intensity or location. Knowledge of the community includes the number of people and the value of property that would be affected by an event, as well as the communications, transportation, food supply or other systems of society exposed to interruption or collapse. The combination of the knowledge of a hazard with the knowledge of a community provides a measure of the vulnerability of the community to that hazard. Hazards analysis may be very refined, with an extensive data base concerning the probability, intensity, location, and community impacts of hazards; or it may be very simple, as when the knowledge that the community is subject to a hazard is sufficient to indicate certain emergency management capability needs.

The Disaster Relief Act of 1974 (PL 93-288) provided development grants to the states for the preparation of comprehensive emergency plans. The inclusion of a hazards analysis was specified, although the guidelines issued to the states were not prescriptive and thus did not provide for plan consistency. FEMA identifies salient aspects of the development and application of hazards analyses. The major challenge in the design of a hazards analysis method is to determine an appropriate balance between quantitative and qualitative techniques. The expected benefits of hazards analysis are detailed, and definitions of related terms are provided. The basic steps of hazards analysis are the identification of hazards; the collection of information; the analysis of information; and the development and preparation of reports.

The federal government should continue to play a major role in providing financial and technical assistance for hazards analysis. FEMA's Comprehensive Cooperative Agreement (CCA) provides a mechanism for the encouragement and partial funding of hazards analysis at the state and local level. Guidance, technical assistance, and training will also be provided. Varying departments and agencies of the federal government should continue to work with FEMA in the development of guidance and technical assistance. Finally, FEMA will work to establish a national data base on hazards, their incident history, probability, and the vulnerability of a community to that hazard. On the state level, each state has the responsibility to identify and analyze hazards and to manage a statewide program to assist local communities in developing their emergency management capability. Like the federal government, the state has responsibilities to provide financial and technical assistance and hazards analysis training opportunities. The state may also play a coordinating and consolidating role by ensuring that communities use guidance in a consistent way. At the local level, each community should undertake an analysis of all hazards to which it is at risk and use the information to improve its emergency management capabilities. Each community can also develop materials for public officials and for the public.

This interim guidance document provides a solid overview and introduction to the process of hazards analysis and its role in effective emergency management.

54

Federal Emergency Management Agency. 1983. The Conceptual Framework for Emergency Mobilization Preparedness. Federal Preparedness Circular 2. Washington, D.C.: Federal Emergency Management Agency.

This document establishes a basic conceptual framework for federal departments and agencies for implementing assigned responsibilities for planning and management of emergency mobilization preparedness. Diagrams are used to illustrate the dynamic concepts of mobilization preparedness.

The framework takes into account a spectrum of emergencies: natural disasters, technological emergencies, resource shortages (including water shortages), civil disorders, and war. Resource shortages are defined as an insufficient supply of a resource on which society has become dependent, where actions are necessary to provide additional resources or substitute, when possible, and conserve existing supplies. Within the spectrum of emergencies, the various roles of government are delineated.

Mobilization categories are established according to the type of resource required to manage emergencies. The seven categories are (1) military mobilization, or the assembling and organizing of military resources; (2) industrial mobilization, or the process of marshaling the industrial sector to produce goods and services; (3) economic mobilization, or the process of marshaling the money, credit, and taxes needed for emergency response; (4) infrastructure mobilization, or the process of marshaling the output of infrastructure systems to support the entire mobilization effort; (5) human resources mobilization, or the process of assembling people to provide needed labor; (6) government mobilization, or the process of marshalling resources of federal, state, and local governments to carry out the tasks required to manage emergencies; and (7) civil preparedness mobilization, or the process of marshaling resources to provide protection for people, industry, and institutions against the effects of the spectrum of emergencies.

The timing of emergency management actions may be considered in terms of four time phases: normal operations; preparation; emergency; and recovery. The overall conceptual framework is extended to assist local and state governments and the private sector in the development of comprehensive programs directed at improving mobilization capability and effectiveness.

The paper offers a useful introduction to the concept of mobilization preparedness and to the many factors involved in achieving emergency mobilization preparedness on various governmental levels.

55 Geldreich, Edwin E.; Harry D. Nash; Donald J. Reasoner; Raymond H. Taylor. 1975. The Necessity of Controlling Bacterial Populations in Potable Waters--Bottled Water and Emergency Water Supplies. Journal of the American Water Works Association 67:117-124.

This article documents findings of a study aimed at (1) investigation of the bacteriological quality of bottled water purchased from retail outlets and the variability of bacterial counts in freshly bottled water and (2) characterization of the changes in the bacterial density of bottled water during storage including the quality of stored emergency water (civil defense).

A total of 129 freshly bottled water samples collected from 25 different bottlers showed 14 bottles (or 14 percent) having an initial standard plate count (SPC) greater than 500 bacteria/ml. Total coliforms were detected in six samples. A total of 101 bottles of unknown age purchased from retail outlets were analyzed and showed that 42 bottles (or 42 percent) contained more than 500 bacteria/ml. A substantial variability of the SPC from brand to brand as well as the variability within the same brand were observed. Finally, 30 water samples collected from 17.5-gallon drums of civil defense that had been stored for ten years showed 21 samples containing more than 500 bacteria/ml after five-day incubation. Total coliform, fecal coliform, and Pseudomonas aeruginosa were not detected in any of the 30 emergency water samples analyzed.

Based on these and other results the authors proposed two recommendations for the bottled water industry and retailers: (1) refrigerated storage will minimize bacterial multiplication in bottled water from the time of bottling to sale; and (2) each container should be marked with the bottling date or lot number to assist the retailer and consumer in determining freshness. The authors recommend a limit of 500 bacteria/ml for freshly bottled water and a permissible increase during storage to a maximum of 1,000 bacteria/ml.

The bacteriological quality of emergency water supplies must be very good because the radiation exposure of injured persons may reduce their white-cell count, impair body resistance to bacterial invasion, and enable harmless bacteria to become serious pathogenic invaders. To protect and maintain good quality of stored water, all emergency supplies should be given supplemental disinfection during annual inspections and before use in an emergency. The disinfection before use is best accomplished by boiling the water for at least one minute or by using commonly available disinfectants such as household laundry bleach, swimming pool disinfectants, tincture of iodine, or various trade-name iodine or chlorine tablets.

56

Graham, David R.; Ronald C. McMaine; and Carroll R. Sweasey. 1984. Emergency Planning for Crisis Management. Lexington, Kentucky: Howard K. Bell, Inc.

The authors outline general steps in emergency water planning and present illustrative case studies of a cyanide poisoning threat and a hazardous materials spill.

The basic steps in emergency planning are to (1) determine potential emergencies; (2) delineate and describe water system components; (3) assign characteristics to the design emergencies; (4) conduct a thorough vulnerability assessment; (5) calculate the demand for water; (6) inventory available resources; and (7) develop an emergency operations plan. Suggestions are given regarding the format and content of an emergency operations plan, particularly for compiling useful reference materials within a series of appendixes. The authors emphasize the importance of basing emergency plans solely on existing resources and keeping plans as concise as possible.

The first case study describes the experiences of the Richmond, Kentucky, Utilities Board when confronted with threats of water supply poisoning in 1983. Guidelines given for implementing emergency response procedures include information on isolating the system, notifying the public and appropriate agencies, and testing for and counteracting the presence of cyanide in the water supply. The second case study describes an oil spill in the Kentucky River in 1983. The emergency response procedures required in this case were the determination of the extent of the pollution, the determination of the appropriate treatment processes, and the establishment of water quality monitoring.

This publication offers concise, useful examples of the development and application of emergency operations plans.

57

Graham, Earl H. 1978. Weather Impact on Water Supply. In <u>Proceedings, American Water Works Association Annual Conference</u>, Paper No. 34-2b, pp. 1-5. Denver: American Water Works Association.

The author describes the impacts of flooding and drought on a large water system by discussing two case histories.

The Philadelphia Suburban Water Company provides water to 210,000 customers residing in 51 municipalities over a 279-square mile service area. The combined capacity of the company's storage exceeds 124 million gallons. The principal source of supply comes from four rural streams supplemented by 18 deep wells and a reservoir. The company also has four interconnections with two neighboring water companies. In 1973, a comprehensive planning study was undertaken to estimate water requirements through the year 2010. This study is revised and updated annually and has shown the water supply to be sufficient through the year 2010. However, even the most sophisticated water plans cannot predict the consequences of weather for water supply systems.

In June, 1972, central Pennsylvania received excessive rainfalls induced by tropical storm Agnes. Four days after the rains began, the flood dike at the Pickering Creek pumping station was breached. The dike elevation of 89.5 feet was 19 feet above the average stream flow. When the inundation began, the plant, which supplied 40 percent of the system's supply, was shut down and all personnel were evacuated. When it became apparent that the switchgear and pump motors would be completely submerged, arrangements were made with equipment manufacturers and contractors to begin restoration efforts as soon as access to the plant could be regained. The prearrangements enabled the rapid restoration of service after the floodwaters receded. On the fifth day, the water level at the station crested at 6.7 feet in the engine room. The quality control department began planning the treatment, backwashing and sterilization of filters, and the disinfection of the clear wells.

Throughout the crisis, the public was kept informed through periodic press releases, which minimized the number of inquiries and increased public cooperation with conservation efforts. Two tank trucks, with 1,750 gallons of capacity combined, were placed into 24-hour service on the fifth day. The next day, it became necessary to lease an additional 10,800 gallons of tank truck capacity to distribute emergency supplies to the public. On the seventh day after the rains began, the first high-lift pump was placed back into service, with full service being restored two days later. The cost of the disaster to the water utility totaled $326,000.

Between January of 1976 and May of 1977, the utility experienced a 7.98-inch rainfall deficiency within the service area. The company was forced to increase the output of the Pickering Creek plant by 9 percent and purchase an additional 22 percent of treated water from a neighboring utility.

The author urges the development of emergency plans by every water utility and notes the benefits of having a distribution system capable of transferring water from one watershed to supplement a deficiency in another. Safety factors should be built into all well systems to ensure their reliability in the event that a portion of the system becomes inoperable. Finally, the author observes that even though a utility has authorized allocations of raw water, there is always the chance that these rights may be challenged.

The article serves both to remind utility managers that the dependability of supply cannot remain constant and to illustrate the need for emergency planning.

58

Grassie, Joseph R. 1975. Maintaining Municipal Services during a Strike. Public Works 106(7):50-51.

This paper emphasizes the importance of an emergency plan to the continued provision of essential public services during a prolonged employee strike. Descriptions of a strike in Michigan are given.

In July, 1974, nearly 900 nonuniformed employees went on strike against the city of Grand Rapids, Michigan. During the 21-day walkout, the supervisory staff of less than 200 were able to sustain a high level of essential public services. At that time, the service area population for municipal utilities was 420,000.

A strike plan was prepared two months before the contract deadline. When city employees strike, the first few days are frequently the most critical and the presence of a contingency plan smooths the transition to emergency conditions. To develop the plan for Grand Rapids, each service offered by the city was analyzed and a determination made to continue all essential services, which included water and sewer maintenance. Each available member of the supervisory staff was placed into a personnel category regardless of age, sex, or job; the entire supervisory staff was utilized. The head of each essential service determined the minimum number of people required for their units, and crew or team assignments were created from the personnel inventory. The work plan and personnel designated for each service were reviewed prior to final plan adoption. An on-site Cross Training Day was held to provide intensive training for the staff assigned to essential services. A critique of each training session resulted in additional exercises being scheduled whenever gaps in knowledge were discovered. In addition to the rapid acquisition of knowledge, a high degree of esprit de corps was attained by participants of the training sessions. No attempt was made to either publicize or keep secret the strike preparations. All preparations were conducted in a matter-of-fact manner, with continuity of services being the primary goal.

Extensive security measures were taken to safeguard equipment and property. Keys to buildings and equipment were collected and fire hazards were double-checked. Trucks and road equipment, including equipment abandoned when the strike began, were taken to a central location and guarded. Such measures minimized incidents of vandalism against company property. Bedding and food were sent to some plants and essential offices so that key people could be available on a 24-hour basis. A complete communications system was established which, along with a daily strike bulletin provided for team members, helped to keep morale at a high level. At one point during the strike, the state Department of Public Health monitored the operations of the water and wastewater treatment plants and determined treatment to be at or above the normal standards.

Following the termination of the strike, a critique was held to evaluate the overall operation of the emergency plan. Each crew chief offered a report of his/her activities and recommendations for improvements. These recommendations were incorporated into the outline of the new strike plan on file.

The author notes one particularly important consideration in strike contingency planning; in order for the plan to succeed, there must be a sufficient number of supervisory people available from outside the bargaining unit. If an adequate number of supervisory or nonbargaining unit jobs cannot be created in advance, then job descriptions should be rewritten so that the city can bargain with the union for new positions outside of the union.

The article provides a useful overview of the development and implementation of an emergency plan.

59

Hall, William D. 1983. Security - Plant and Office. Paper presented, Annual Meeting of the Indiana Section American Water Works Association. Indianapolis.

This paper lists various security measures that can be adopted by water utilities to increase system protection.

The three sources of criminal threat to water utilities are vandalism and terrorism (external sources) and theft by employees (internal source). Bomb threat is discussed to provide examples of utility protection and response measures. Measures to secure the area surrounding utility structures include (1) storing trash containers away from structures; (2) keeping shrubs and foliage away from structures; (3) securing all subterranean access points such as manholes and ducts; (4) illuminating basement access points and blocking these openings with heavy mesh wire; (5) locating parking areas away from structures; (6) removing or beveling ledges, especially in rear areas; (7) illuminating porches and leaving ground-floor lights on at night; (8) removing access ladders to the roof; (9) coating drain pipes or lower support areas with anticlimb paint; (10) not allowing rubbish to accumulate, particularly on ground-floor or basement levels, which could conceal explosive or incendiary devices; and (11) sealing letter box openings and night deposit boxes if faced with bomb threats. Emergency operation plans might include forms designed to record information useful to the analysis of bomb threats or other threatening calls. Prolonging calls, when possible, may result in gathering information useful to investigators. The primary benefit of established response forms is that all employees, whether trained or not, can respond appropriately by following the form.

Financial security measures include cash controls, such as limiting access to cash drawers; keeping receipt stubs separate from the cash box; periodically removing cash from collection counters to minimize the amount vulnerable to robbery; and depositing cash at least twice daily to minimize the accumulation of vulnerable cash. Materials payment controls require evidence of materials having been received before any payment is made and permit price comparison controls to prevent the ordering of higher-priced material in order to obtain favored treatment by the selling agent or supplier.

Prompt accident investigation may improve the results of investigations, reduce insurance claims, and minimize losses. Electronic data processing equipment protection includes (1) off-site backup for daily and monthly runs; (2) moving backup off-site daily; (3) ordering special nonstock forms well in advance, with partial shipments to ensure supply; (4) developing a backup agreement with an organization using the same type of equipment; (5) having program documentation stored off-site; (6) assuring phone access to outside areas when a single employee is on duty; and (7) minimizing the amount of time that a discharged employee spends in the electronic data processing section to reduce the chances of retaliatory vandalism. Security measures to protect employees who must work alone include providing cordless telephone service and having the employee call an answering service or operate a key box hourly so that someone will respond if the hourly contacts are not made. Utilities should maintain updated emergency operations plans that include provisions to reduce looting by familiarizing local law enforcment personnel with utility facilities and prearranging for National Guard assistance.

The needs of utilities for alarm systems differ as systems differ. Factors involved in the selection process include an assessment of (1) the type of threat or risk; (2) the type of sensors needed for various elements of the utility system; (3) the alternative methods available to provide the level of protection needed; and (4) the method of alarm signal transmission (how the message will be sent and to whom). The successful operation of a system depends on proper installation and maintenance by the alarm company and on proper use by the customer. The three parts of an alarm system are (1) sensing devices, which sense intrusion or respond to abnormal conditions; (2) control facilities, which receive the signals and process them; and (3) alarm transmission/signaling, which triggers the local alarm or notifies someone off premises for further action. There are two categories of sensing devices. (1) Perimeter (point of entry) protection covers all openings to the building. Over 80 percent of all break-ins occur through these openings; most alarm systems provide perimeter protection. Several devices are described. (2) Interior, or space protection, should always be supplemented by perimeter protection. Devices, including photoelectric eyes, ultrasonic, infra-red, pressure mats, sound sensors, and more, are described.

Alarm control panels that receive and process sensor signals include a backup power source. Control panels may be connected to a central monitor station. Alarm transmission/signaling system selections depend on the location of the protected facility, the frequency of police patrols, and the customer's ability to pay. Two types of systems include local alarms, where a bell or light indicates an intrusion and the intruder is aware of detection, and central station systems, where the alarm signal is transmitted to a staffed, central station for response. The advantages and disadvantages of various central station systems are discussed. Additionally, a list of outdoor protection systems is given.

The author provides a comprehensive review of security measures useful to utilities in the development of security programs.

60

Harmon, Judson A., and Harvey F. Ludwig. 1964. Recovery and Restoration of Water Utilities after Nuclear Attack. Journal of the American Water Works Association 56:1561-1577.

The authors review the potential effects of nuclear weapons on water supply systems and suggest appropriate preparedness and response measures.

The negative impacts of nuclear explosion on water system equipment and structures are due to blast and shock forces and thermal radiation. Damaging effects on personnel and water supplies result largely from the initial ionizing radiation and radioactive fallout. The general destruction and postattack fires exacerbate difficulties in repair and restoration. Blast and shock forces and thermal radiation will affect approximately the same area, while early fallout will affect an area 10-100 times greater.

A nuclear attack will produce conditions that can be characterized as (1) isolation, (2) radioactive fallout, and (3) physical damage. The extent of these conditions will depend on the location and magnitude of attack as well as on conditions prior to the attack. Isolation may result from disruptions in the movement of supplies and personnel into the water utility area; from excessive radioactive fallout; from damage to aqueducts, dams, bridges, highways, railroads, airports, or communication facilities; and from the interruption of power supplies or water delivery from remote sources. The water industry may have to rely solely on the use of local facilities, supplies, and personnel for some time after a nuclear attack. Radioactive fallout would injure and kill personnel not adequately sheltered for an extended period after attack; subject exposed water surfaces to radioactive particulate matter; and deposit radioactive dust on all exposed surfaces of structures, equipment, and work areas. Protected groundwater sources should not receive significant radioactivity if surface facilities are not damaged, nor should water in undamaged protected-storage facilities and distribution piping systems.

Most physical damage would result directly or indirectly from the blast wave accompanying the explosion. Broken gas mains and electrical short circuits would produce fires. The blast would also produce flying missiles such as masonry, glass, wood, and metal that would cause numerous casualties and significant secondary damage to structures. Due to physical damage, the availability of water might be a greater problem than fallout contamination in the period following attack. Distribution systems might suffer damage to reservoirs, fire hydrants, service lines, or shallow mains. Surface supplies might be affected by damage to intake or impoundment facilities. Damages within the watershed might result in the discharge of hazardous materials from land installations or boats and barges. Wells might be affected by damage to aboveground structures or by flooding. Water turbidity would increase. Thermal radiation would ignite inflammable structures such as reservoir roofs, wooden poles supporting communication or power lines, and buildings housing critical materials and equipment. Extensive fires could also contribute to the risk of hazardous materials spills. Personnel would be affected by both the blast and thermal radiation. Blast impacts would include injuries to eardrums and lungs due to overpressure; injuries from wind pressure pushing people into hard surfaces; and injuries from being trapped inside collapsing structures or struck by flying debris. Thermal radiation could cause burns from the absorption of radiant energy by the skin or from radiation-induced fires.

The preparedness measures discussed include (1) conducting a vulnerability analysis; (2) strengthening structures and facilities to minimize damage; (3) training staff in emergency operations and utility recovery under postattack conditions; (4) establishing shelters for essential personnel at locations that would facilitate emergency operations and recovery; (5) planning radiologic protection measures for personnel throughout the recovery period; (6) stockpiling essential equipment, material, and supplies in sheltered, dispersed locations; (7) establishing mutual aid and joint-venture agreements; (8) inventorying and planning for the use of auxiliary supplies; and (9) developing civil defense/emergency operations plans that delineate response procedures.

Following a nuclear attack, countermeasures to isolation are to conserve water, equipment, material, and supplies; to prepare to provide assistance to others when possible; and to establish contact with other utilities and with parties involved in mutual aid agreements. Countermeasures to radioactive fallout danger to personnel are to keep exposures within acceptable levels by sheltering; to monitor levels of radiation and control entry time and stay time within tolerable limits; to decontaminate high-priority work areas and facilities; and to avoid low-priority areas and defer all but essential operations. Countermeasures to fallout danger to water supplies are to use groundwater supplies, supplies in sheltered storage, and auxiliary supplies; to monitor surface water supplies and use those with the least contamination; to modify treatment plant operations to accomplish removal of radioactivity and other contaminants and to conserve chemicals and supplies; and to improvise dual water supply systems so that better quality water can be strictly allocated and lesser quality water can be used wherever possible.

Countermeasures to material damage include the conservative use of surviving facilities, equipment, and materials; the use of surviving stored supplies; the isolation of undamaged facilities from damaged facilities; the controlled allocation of water to satisfy only minimum essential needs; the use of alternate sources of supply and facilities through temporary construction and improvised operations; and the repair and restoration of damaged facilities. Repair and recovery decisions would depend on the relative importance of the facility or area and the consequences if restoration is postponed; the existing radiation intensity of the facility and area; the time necessary to make the facility functional; the number and condition of trained personnel and equipment available to accomplish restoration; the feasible decontamination procedures; and a careful evaluation of all alternatives.

This article provides a thorough, detailed discussion of the impacts of nuclear war on water supply systems and could serve as a valuable reference to utility managers seeking to develop preparedness and response capabilities.

61

Hazen, Richard. 1975. Managua Earthquake: Some Lessons in Design and Management. Journal of the American Water Works Association 67:324-326.

The author recounts the effects of the 1972 earthquake on the Managua water supply system and details recommendations to increase the system's resistance to future disasters.

In 1972, the population of Managua, Nicaragua, numbered nearly 400,000. The water supply system was fed principally from Lake Asososca, an extinct volcano crater west of the city. Managua sits on a line of volcanos that extend nearly the full length of Nicaragua. Earth tremors are common, and devastating earthquakes occurred in 1931 and 1972. The 1972 earthquake measured 6.5 on the Richter scale.

The Lake Asososca pumping station is located on the steep slope of the crater. Although the access road was destroyed by slides of the crater walls, the pumping station, force main, anchor blocks, and immediately adjacent ground were undisturbed by the earthquake. The facilities had been designed to be earthquake resistant. Anchor bolts around the base of the surge tank adjacent to the pumping station sustained an elongation of five-eighths of an inch. The bolt elongation was nearly uniform around the circumference of the tank, indicating that the structure had been rocked back and forth by the tremor. After the earthquake, four wells, yielding 2 mgd, were drilled on the south side of the city to supplement supplies from Lake Asososca.

The transmission and distribution systems sustained major damage. Two months after the earthquake, 400 water-main failures had been located and repaired, yet inordinately high water pumpage indicated that many leaks remained undetected. In the center of the city, destruction was so extensive that no immediate attempts were made to restore service; laterals were simply valved off at both ends. The water-main failures were primarily caused by lateral and vertical movement of the earth, as much as 20 and 10 cm, respectively. Asbestos-cement pipe and old gray-iron cast pipe failures were mostly shear breaks across the barrel. In large diameter pipes of both ductile iron and gray iron, failures were caused by joint separation rather than pipe breakage. Other service failures usually occurred at the corporation-cock or meter-box connection. Saddles were used for service connections to asbestos-cement pipe but not for cast iron. Prior to the tremor, there were 38,000 connections, 100 percent metered. Overnight, connections dropped to 17,200. In spite of this, water pumpage two months after the earthquake equaled that of before the disaster.

Three 2.5 mgd reservoirs were in service at the time of the earthquake; a fourth was empty due to maintenance and repairs and sustained less damage than the others. Earthquake damage included (1) vertical and horizontal hairline cracks in the walls; (2) cracks from inside to outside of walls and from bottom to top of foundation walls; (3) settling of columns and foundation walls, as much as four inches, causing failure of water stops and seals; and (4) circumferential cracks at both top and bottom of the inside columns. Additionally, large flows of water through the cracks and breaks eroded the soil beneath the slab and foundation walls. Grouting below the tanks should reduce washouts in future earthquakes, but structural failures can be expected.

Steps to minimize the impacts of future earthquakes on the city's water system include (1) developing a flexible lining for reservoirs and designing smaller-capacity tanks; (2) developing a second water supply from a less vulnerable source; (3) using nonbrittle pipe for water mains and services, with flexible connections; (4) maintaining a large stock of tools, excavating equipment, trucks, and repair supplies; (5) enlisting an auxiliary repair force to serve in emergencies, such as employees of contractors and plumbing concerns; (6) developing a program so that the less damaged parts of the system with an operable source can be quickly segregated and kept under pressure; and (7) maintaining standby engine-driven pumps on two or three wells to provide an immediate supply of potable water in an emergency.

The article offers useful information to planners seeking to increase the earthquake resistance of water supply systems.

62

Hegenbart, Joseph L. 1973. Use of Telemetry and Remote Control in Naturally Occurring Disasters. Journal of the American Water Works Association 65:155-157.

The author evaluates the advantages and disadvantages of telemetry and remote control functions in the aftermath of a natural disaster. The article includes illustrative case studies.

The author contends that telemetry and remote controls retain a limited usefulness in emergency situations. The operation of the Los

Angeles water system following the San Fernando Valley earthquake of 1971 is discussed to illustrate the post disaster utility of electronic monitoring and remote control. The characteristics of the water system and the damages incurred are listed, as are the procedures necessary for damage assessment, decision making, and implementation of service restoration decisions. The advantages of telemetry are: (1) it provides the ability to rapidly assess (superficially at least) the damage to a water system, and (2) where telemeter equipment continues to function properly, personnel who would be required for surveillance purposes are released to other activities. The disadvantages are: (1) the costs of installing and maintaining telemetry equipment are high--only certain points of the system can be telemetered and these points may or may not be sufficient in cases of emergency; (2) the information provided by telemeters may be incomplete and require field assessments to verify true conditions (e.g., a telemetered tank which records a normal level but is in danger of collapse); and (3) electronic monitoring devices can be unreliable during many emergencies due to power outages, damage to equipment following structural collapse, arcing between communication lines due to high winds, or destruction of lines due to brush fires. The advantages of remote control functions are (1) ability to speed implementation by initiating activities without dispatching crews to distant facilities and (2) rapid closure of control valves to conserve storage of vital supplies during an emergency. The disadvantages are (1) high costs limiting the selection of remote-controlled facilities; (2) vulnerability of power and communication facilities and of the control center itself; and (3) necessity to conduct some activities manually due to system repair, flushing, or chlorination.

The author illustrates the need for a competent hydrographic staff and adequate maintenance and operating personnel in the field to provide the flexibility that is needed during emergency situations but not provided by electronic systems alone.

The article offers a clear, concise evaluation of the use of telemetry and remote control in emergency situations that is well supported by case histories.

63
Higgins, Clay E. 1985. Shedding Light on Utility Security. Security Management 29(5):79-82.

This article reviews problems faced by those involved in the relatively new field of utility security management and recommends strategies for addressing these concerns. Illustrative examples from the electric utility industry are provided.

The author notes that utility security is a relatively new specialty in the industrial security field. In most cases, each utility meets its individual security needs on a property-by-property basis; there are few national standards, beyond those set for nuclear sites. Most problems faced by utility security directors are not new to the security industry; however, they must also contend with little exchange of security information among utilities, the lack of mature security organizations within utilities, and the lack of printed material on utility security.

Security requirements vary from facility to facility, but some problems are fairly common. The loss of tools from service vehicles that must be fully loaded even when not in use may be addressed by preparing a general written inventory of items on all trucks, and requiring all persons who sign for vehicles to be responsible for major expendable items, or by maintaining close surveillance of parked vehicles at operations centers. The loss of stored items from storage sites and warehouses lacks a single solution; the answer lies somewhere between good inventory control and tracking procedures and eliminating the honor system for logging out supplies; the use of card access controls may help, as well. Outstation and distribution center security may be augmented through the use of sliding automatic gates and card access controls at gates used for vehicle entrances; lock-and-key control procedures often suffice for smaller sites. Distribution centers may offer the most opportunity for theft and trespass problems due to the wide range of equipment, tools, and materials maintained at these locations. The main problem in providing security for these installations is cost; security expenses must be viewed as insurance in order to be cost-effective.

Construction site security may prevent major losses. Theft at construction sites usually occurs during the daytime, when many utility and construction company employees are at the site. The key is not allowing tools and materials to leave the site--if contractor tools must be used, inventory tools as they enter the site and do not allow them to be removed until the job is complete. Closely inspect all vehicles coming and going from the site, and keep a log of all vehicle movement on- and off-site. All personal vehicles should be parked off-site and all employees or contractors must wear identification badges and enter the site at controlled points. As with any large corporation, utilities have many high-value items as well as sensitive information that requires protection, such as subscriber credit histories, financial data, personnel records, and computer information. Central control centers are extremely vulnerable as well, so that building access controls represent a vital component of utility security. Solutions include card access systems combined with additional protection measures such as locks and keys, guards, alarms, and guard dogs.

Money-handling and holdup security procedures may frequently be adapted from those developed by the banking industry. In addition, banks have pioneered the use of panic alarms and recording equipment for video cameras as effective deterrents. Emergency planning is central to security programming. Fires, bombs and bomb threats, and robberies are all security considerations. Utilities need detailed bomb search and evacuation plans for all sites; plans should be practiced and employees should be trained to meet specific responsibilities. Additionally, contingency plans for security emergencies must be integrated with facilitywide emergency plans. Office building security requires a diverse protective organization. Threats may be classified as natural or man-made and include fire, theft, holdups, trespassers, bomb threats, riots and civil disorders, disgruntled employees, unhappy customers, psychopaths, and the threat of extortion or hostage taking. Diversion, or the use of resources without paying, may often involve collusion with utility employees. Programs should be established to reduce the occurrences of such losses, provide good investigations, and prosecute violators. One method is to monitor monthly usages, establish norms, and have the utility's computer compile a list of customers whose usage exceeded or was less than normal. An active investigative unit can then conduct appropriate checks for criminal activity.

A management approach should be applied to security problems. Security managers should define problems, select alternative solutions, present final recommendations in the formats used to conduct business within a particular organization, and be prepared to justify recommendations in terms of corporate policy and cost. To determine threats, make a threat study and conduct a crime study of the environment surrounding each facility to be protected. Analyze the risk, developing a method to measure the value of the plants, equipment, and materials at risk. Evaluate the cost of recommended solutions by comparing the cost of different solutions and developing the rates of return on dollars invested and the payback period. Utility security professionals must borrow techniques and programs from computer facilities, banks, retail organizations, and office buildings. Additionally, security managers must be familiar with cargo and transportation security, physical security, alarm operations, executive protection, and emergency planning.

The author provides an in-depth examination of complex utility security considerations. Although electric utility security is emphasized, the article could be extremely useful to water utility managers as well.

64

Hooker, Donald. 1981. A Regional Response to Water Supply Emergencies. Journal of the American Water Works Association 73:232-237.

The author describes the Washington Water Supply Emergency Agreement (WSEA), which is a coordinated areawide water conservation and water use plan. The paper reviews the components of the WSEA and the agencies involved.

The Washington Water Supply Emergency Agreement is described as a unique cooperative regional effort of major water supply agencies operating within 19 political jurisdictions in two states and the District of Columbia. The WSEA was created in response to drought conditions in 1977 and required two years to reach official agreement. The emergency plan covers water emergency conditions caused by extreme shortages, equipment failures, sabotage, or pollution. The plan not only coordinates areawide water conservation and curtailed water use during periods of critical water supply shortages but also facilitates tailored water consumption based on combined quantities available to the regional signatories.

The plan specifies actions to be taken by the water suppliers at the alert, restriction, and emergency stages as well as specifiying exact media information for release at each stage. Alert and restriction stages call for voluntary customer measures; however, the emergency stage mandates compliance and includes enforcement and penalties. Water shortage stages are defined by the Potomac River Low Flow Allocation Agreement, which identifies Potomac River fluctuations and allocates available water to suppliers according to a set formula.

This concise article provides a comprehensive description of a carefully developed regional contingency plan. The article does not discuss the evolution of planning which culminated in the agreement, nor the types of potential penalties that could be levied on noncompliant customers during emergency stages of a water shortage.

65
Hrezo, Margaret S.; William R. Walker; and Phyllis G. Bridgeman. 1984. Water Allocation during Water Shortages. In _Legal and Administrative Systems for Water Allocation and Management: Options for Change_. Blacksburg, Virginia: Virginia Water Resources Research Center.

This study considers alternative strategies for managing water shortages as taken from a range of alternative institutional approaches to current water management issues in the Southeastern United States.

William E. Cox provides a concise summary in his introduction and overview:

> Criteria developed for evaluation of alternative approaches include an assessment of whether the strategy: (1) allows the formation of user expectations; (2) reduces the waste of water; (3) accommodates competing interests; (4) protects instream water uses; and (5) satisfies constitutional requirements. Application of these criteria to common law systems of surface and ground water allocation results in the identification of several deficiencies.

To identify alternative approaches to the resolution of these deficiencies, the paper presents a survey and analysis of allocation mechanisms that have been developed for use during water shortages within the 48 contiguous states. This analysis results in identification of three general categories into which the individual states can be classified: (1) Category 1, consisting of 14 states, includes states that rely primarily on their allocation systems to meet unexpected shortages without empowering any entity to plan in advance for drought; (2) Category 2, consisting of 27 states, includes states that have plans for meeting supply shortages, but most are emergency responses rather than advance planning efforts to mitigate the effects of drought; and (3) Category 3, consisting of 6 states and a river basin commission, includes states with relatively comprehensive institutional mechanisms for allocation of water during shortages. Specific institutional options presented as alternatives for allocation during water shortages include (1) encouragement of water conservation through economic incentives and education; (2) initiation of statewide planning for water shortage management; and (3) implementation of a comprehensive shortage management program within the framework of water use permitting.

Although this study focuses on water shortage or drought planning, most of the assessed state laws pertain to emergency planning for all types of disasters, water-related or otherwise. Therefore, the survey represents an overview of the states of emergency water planning from all 48 contiguous states.

66
Ikle, Fred Charles. 1958. <u>The Social Impact of Bomb Destruction</u>. Norman: University of Oklahoma Press.

This book estimates the sociological and demographic impacts of widespread bomb destruction and relates the physical effects of nuclear destruction to their social consequences.

Mankind's actual experience with nuclear bombings of cities is limited to the explosions at Hiroshima and Nagasaki. The only empirical evidence with which to examine the effects of nuclear bombings comes from those cities, yet those explosions resulted from single atomic weapons far smaller than those stockpiled today. Additionally, the explosions occurred near the end of the war, so that there is little evidence of the effects of nuclear bombing upon continued war efforts. Substitutions for the missing evidence may be made by examining the effects of physical damage of other wartime and peacetime disasters on social and economic phenomena and by using data from natural disasters and World War II bombings to discover how social effects change with varying degrees of destruction. However, the possibility exists that entirely new social or psychological factors may result from destruction as extensive as that likely to accompany nuclear attacks.

The city is a complex of interrelated physical and social functions that may be represented by separation into functionally homogeneous relationships, which consist of two components: "resources" and "consumers." The consumer-resources ratio reveals the relationship between the two. This ratio is elastic with respect to destruction and disruption; the degree of elasticity is determined by (1) predestruction consumer density (or resources scarcity); (2) divisibility of resources or consumption; and (3) organizational problems. Another important concept is that of the disproportionality of effects from increasing destruction. After physical destruction exceeds a certain percentage of the city's total resources, further increases in destruction will result in disproportionately greater increases in social effects. The phenomena of elasticity and disproportionality apply not only to cities but also to regions or a country as a whole.

The author groups water supply, electricity, gas, and other fuels and the sewage and garbage disposal systems together because the vulnerability of their physical resources is rather similar, and they have a multiple effect upon the network of other urban functions, such as transportation and communication systems. Partial housing destruction is likely to disrupt the system of distribution of water, electricity, and gas, so that many serviceable dwellings that remain will be deprived of essential utilities. If these services, especially the water supply, cannot be quickly restored, the inhabitants will waste manhours because of housekeeping difficulties, or they will abandon the city. Immediately after a bombing attack, the urban water supply may be severely depleted due to damaged mains and huge fire-fighting demands. During World War II, the Hamburg water supply was seriously disrupted. Many pumping stations were either destroyed or deprived of power supply. Auxiliary wells did not provide sufficient potable water, so that available sprinkling cars and tank trucks had to be utilized for public water distribution. Destruction of all pipe-cutting machines impeded the repair of water mains. The water supply in Hiroshima declined by about 30 percent after the atomic explosion but had returned to the predestruction level within five months; the distribution system, however, took much longer to restore. In Tokyo, the urban water supply did not, on the whole, suffer from the World War II bombings.

A prolonged lack of water would render habitation of a city or urban district impossible. This did not occur during World War II, except where officials decided to totally abandon a damaged area and not institute repairs. The sewage system is the least vulnerable of all utilities because it is completely underground. Large raids in Hamburg caused occasional damage to sewers, but no serious effects from damaged sewers are reported for any city bombed during World War II. A disrupted water supply will put flush toilets out of service, which, as evidenced during World War II, can create problems of major concern in densely developed areas. Generally, maintenance and housekeeping utilities have an elastic consumer-resources relationship. No specific mention is made of the possible implications of radioactively contaminated water supplies.

Other topics addressed include casualties and their consequences, the destruction of housing and its impact on population, evacuation as a preventive and adaptive process, food supply and the supply of other consumer goods after bombing, the total effect on urban manpower, the cumulative impact on the national war effort, and the postwar results of bomb destruction.

The book is extremely informative and thoroughly examines the consequences of physical destruction for social systems.

67

Illinois Environmental Protection Agency. 1983. Emergency Planning for Drinking Water Systems. Division of Public Water Supplies. Springfield: Illinois Environmental Protection Agency.

The manual is designed to help community public water supplies to be prepared for emergency action, should the occasion arise. It may also be useful for industries, commercial establishments, and other organizations with their own water supply systems. The report is both evaluative and advisory.

The four sections of the manual review existing state plans for provision of safe drinking water under emergency circumstances, an emergency plan checklist, a checklist of the elements of a statewide emergency plan, and an emergency equipment source list with other possible sources to provide emergency water supplies. The appendices include guidelines for reviews of the adequacy of state emergency plans; the Illinois Environmental Protection Act; parts of the Illinois Administrative Code pertaining to public water supplies and rules and regulations governing water supply operators; the Water Supply Operator Certification Law; guidelines for dealing with contamination of public water supply; a county emergency operations simulation; and a directory of the Illinois EPA.

Statutory authority over the provision of safe drinking water lies within the IEPA. Inside the IEPA, the Division of Public Water Supplies (DPWS) is responsible for programs pertaining to the provision of safe drinking water. DPWS works with the Illinois Emergency Services and Disaster Agency (ESDA) to maintain emergency preparedness. No specific statewide emergency plan is detailed in this report.

The various guidelines and checklists are useful in detailing the process of developing an emergency water supply plan, as is the county emergency operations simulation.

68

Inman, Lloyd V. 1981. Mt. St. Helens and the City of Longview Water Supply. In Proceedings, American Water Works Association Annual Conference, pp. 1163-1170. Denver: American Water Works Association.

This article describes the impacts of a volcanic eruption on a community water supply system. Detailed descriptions are given of the water supply process from the time of the eruption to the reinstatement of normal conditions one year later.

On May 18, 1980, the Longview, Washington, water utility received word that Mt. St. Helens had erupted after two months of increasing volcanic activity. At the time of the eruption, normal water conditions in the Cowlitz River were excellent; the water temperature was 51 degrees F., and turbidity averaged approximately 5 NTU. Shortly after the eruption, the river area was evacuated in preparation for expected flooding. Approximately 24 hours after the eruption, the river temperature had risen to 90 degrees F. and turbidity was close to 70,000 NTU's. Testing with an Imhoff Cone revealed nearly 880 ml per litre of settleable solids. The water was unsuitable for use, necessitating emergency measures. The public was urged to conserve supplies by restricting use to essential uses only, and all large volume users were required to discontinue use until further notice. Three alternative sources of supply were available. Connections with a large timber manufacturing plant allowed water to be accepted back into the city system from the plant system. The city of Kelso received water from a river intake Ranney device located 18 feet beneath the riverbed as well as from the city of Longview's system, so that provisions could be made for pumping water from the city of Kelso into Longview's water system. Additionally, limited amounts of potable water containing 2-3 ppm of iron were obtained from another large manufacturing facility. The sampling of water at various stations in the city was increased from 12 times per week to 12 times per day; no bacterial contamination was discovered.

The raw water pumping station was filled with nearly 26 feet of fine silt and sand. The total cost to clean the pump station was in excess of $75,000. Three days after the eruption, an old pump station had been refitted to provide water to the treatment plant. River turbidity at this time was 1,800 NTU's, with a ph of 6.7 and a water temperature of 53 degrees F. Four days after the disaster, the city of Kelso's Ranney well system had begun to fill with fine silt, so that the city had to cease providing Longview with auxiliary supplies. Throughout the rest of May, the city of Longview struggled to increase supplies by reviving older facilities and by adapting the treatment process to the highly turbid water. By June 1, the turbidity had decreased to 400-500 NTU. Filters that had been washed once every 24 hours were being cleaned every six hours to accommodate the increased solids load. Settling basins that had been cleaned out once per year were requiring cleaning every 5-6 weeks. Fortunately, the presence of two settling basins permitted the use of one while the other was being washed.

The U.S. Army Corps of Engineers began dredging the river in July. The dredging lowered the water level in the river and increased turbidity in areas where the dredges were working, creating continuous difficulties for the water treatment plant. Due to the fluctating river elevations and the need to clean the screens every 24 hours, water crews rigged a boom and pulley arrangement to lift the screens when needed. The presence of high silt and sediment levels at the point of intake proved to be the most constant problem faced by the utility during the year following the eruption. Continuous efforts were made to keep the intake area clear. Finally, in March, 1981, the Corps of Engineers dredged the area immediately surrounding the treatment plant intake, and full plant operation was resumed for the first time since May, 1980. Two special silt sills were designed to be placed in the face of the intake facility to prevent silt from entering the treatment plant. The treatment plant was equipped with continuous reading turbidimeters, which proved to be valuable to the Water Department's efforts to provide water service under the unusual conditions produced by the volcano.

The article provides an interesting view of the potential effects of volcanic explosions on water supply and treatment facilities, and could be very instructive to utilities located in areas vulnerable to volcanic activity.

69

Jackson, Ray A. 1975. Disaster Planning Aids Water Utility Operations. Water and Sewage Works 122(7):92-93.

Using examples from the state of Virginia, the author reviews the basic components of a utility emergency operations plan.

Disaster is defined, according to the AWWA Manual on Emergency Planning, as "an event, natural or man-made, which is concentrated in time and space and which causes a community or a specific subdivision of a community to suffer danger or disruption of normal functions." A distinction is made between disaster and routine operating problems. The emergency plan of the state of Virginia divides the state into twelve emergency water areas with water utility personnel as water directors and assistant directors. Flooding is listed as a common disaster in Virginia, although parts of the area are in areas of seismic risk. The author recommends references pertaining to emergency operations planning and discusses vulnerability analysis, noting that certain protective and planning measures will be common to most types of disasters.

The city of Richmond's disaster plan consists of an organization chart, complete staff listings, operation and field headquarters sites, staff duty assignments, identification data, a description of nondisaster emergencies, and an equipment inventory for each department. The Utilities Department has a single detailed operating procedure, which pertains to flood hazards. The flood procedures are prepared by each division chief to maintain clearcut responsibility and accountability.

The development of an emergency operations plan results in better responses to routine operational emergencies, as well as to disaster situations. Due to increasing distances between employees' homes and their place of work, rapid emergency mobilization may be difficult to achieve. Equipment should be kept ready for use and backup equipment should be available whenever possible, with alternate operators trained for all equipment. Maintaining strong relations and cooperating with other agencies is very important, and the author notes that visualizing problems from the other agencies' points of view may facilitate emergency coordination. Communications are vital during a crisis, and reliable backup systems should be available in the event of disrupted communication services. The author suggests that the telephone company be contacted in advance to arrange priority status for utility telephone service. Backup power sources are always crucial, and backup equipment should be operated periodically under full load to ensure constant readiness. Reliable stocks of materials and emergency supplies should be maintained.

The article is useful and addresses many important elements of emergency planning for water utilities.

70

Jensen, Robert G. 1982. Creating the Denver Water Department's Security Program. Journal of the American Water Works Association 74:508-511.

This paper explores the evolution of a comprehensive security program for water utility management. The author reviews the experiences of the Denver Water Department in developing their security program.

Prior to 1975, security at the Denver Water Department was largely ignored. At that time, management realized that the utility had many vulnerabilities, including 20 dams and reservoirs; ownership of real property in 11 Colorado counties; ownership and operation of three treatment plants; ownership of assets worth approximately $1.5 billion; 950 persons employed; a 350-square-mile service area with a population of 1 million; ownership of more than 400 vehicles; ownership of two separate, highly sophisticated computer systems; the processing of funds in excess of $80 million annually; the instigation of a $150 million capital improvement program; and inventories and warehouse materials valued at over $30 million. In recognition of these vulnerabilities, the department began to develop a comprehensive security program. Initially, the security function was assigned to the plant division, which was the largest and most directly involved with employees and operating facilities. For the first three years, security consisted of responses to specific problems already identified and of routine security procedures such as the installation of a modern lock and key system and the maintenance of a basic security guard system.

A risk management program was initiated along with the security program. Risk management is defined as an overall effort to deal with human and financial exposures incurred as a result of an entity's normal operations. Effective risk management cannot increase revenue, but it can reduce the cost of losses. The department hired a risk management consultant who reemphasized the importance of a security component to an overall risk management program. Over time, the security program was integrated into the safety section to minimize resistance to the implementation of a new program. The support of upper management was obtained when, as a result of initial security efforts, insurance costs were reduced significantly, while coverage actually increased. A general policy statement was drafted to establish security as a part of the overall risk management program. A former division chief of the Denver Police Department was hired as an independent security consultant, which provided invaluable access to the security resources of the various police organizations in the Denver metropolitan area.

Since 1979, the accomplishments of the security program have included the following:

1) A discovery was made of a significant misappropriation of department property.
2) The central administration building, identified as high-risk, has received special protective measures.
3) The exposure of caretakers at remote facilities has been addressed by obtaining German shepherd dogs trained by the Denver Police Department.
4) A remote entry system is being developed that will permit the central control dispatcher to monitor entry at remote pump stations.
5) Security systems to detect unauthorized intrusions as remote facilities are being designed and installed.
6) The security section has assumed complete control of managing the contracted security guard system.
7) Facilities to protect the department's cashier operation have been modernized and improved, with an alarm system tied directly to the Denver Police Department's control desk.
8) The security section, working closely with the Denver Police Department in the spring of 1981, conducted an extensive undercover investigation resulting in the termination of 12 department employees for drug-related offenses.
9) The security section assists, on a daily basis, in investigating matters relating to personnel problems, vandalism, unauthorized appropriation of department property, vehicle accidents, safety violations, and routine observation of department activities.

10) Relationships with local police and fire departments have been significantly improved, resulting in improved coverage of department facilities.

The most significant achievements have dealt with internal, rather than external, security problems. The author notes that a commitment to security by employees is the first critical step in any overall security effort. Other critical processes include the coordination of security efforts with the ongoing efforts of other local organizations and the maintenance of internal communication and coordination. Part of the security sections's responsibility is dealing with fire evacuation plans, bomb threats, disaster plans, security system plans, internal control procedures, and dam and reservoir security programs. The author emphasizes that security programs must support, not interfere, with ongoing obligations.

The article is complete and informative, providing useful information on the development of a security program and the benefits that may result.

71

Kachadoorian, Reuben. 1976. Earthquake: Correlation between Pipeline Damage and Geologic Environment. Journal of the American Water Works Association 68:165-167.

The article examines the relationship between geologic environment and the damages to pipelines from earthquakes to aid engineers and utility managers in planning for earthquake resistant designs. The author recounts the effects of various earthquakes and reviews engineering techniques.

The intensity and distribution of damage and type of failure a pipeline undergoes during an earthquake are chiefly a function of the geology underlying and surrounding the pipe and the type and use of pipe. A pipeline system is subjected to direct and indirect effects of earthquake. Direct effects include regional uplift, regional subsidence, fault displacement, and tectonic shaking. Indirect effects are seismically triggered mass movement of the ground and include landslides, fractures, lateral displacement of sediments, differential settlement of sediments, and compaction of sediments. Pipelines buried in or supported by fine-grained sediments are more prone to damage from seismic events than pipes underlain by bedrock or coarse-grained sediments. Ground motion has greater magnitude, longer durations, and more damaging low-frequency waves in fine-grained sediments, and these effects are significantly magnified if the sediments are saturated or if the water table is close to the surface. These factors played a major role in pipe damage during the San Fernando and Alaska earthquakes. Seismic shaking places part of the pipe in tension while, at the same time, another part is in compression. Where pipes are in tension, they try to part, usually at joints; where in compression, they either buckle or if already parted, try to reseat themselves. In some instances, if pipes do not fail from the compression mode, internal pressures within the essentially noncompressible water become great enough to blow out valves. The author details earthquake engineering aspects of various geologic environments and urges utilities to carefully consider the geologic, hydrologic, and engineering characteristics of a pipeline route before construction. In some cases, an initially more expensive alternate route will be justified over time by its greater durability.

The article is very well written and contains a great deal of information about the behavior of pipelines under seismic stress.

72
Kupperman, Robert H. 1978. Industry, Terrorism and the Bottom Line. Security Management 22(8):14,17,52.

The author, chief scientist for the U.S. Arms Control and Disarmament Agency, offers preventative measures, recommendations, and practical contingency planning for minimizing the threat of terrorist assaults.

Terrorist assaults--kidnappings, assassinations, and sabotage--on corporations increase the cost of doing business. Although no relief from such attacks is apparent, the author contends that the costs, whether measured in dollars or in morale, can be minimized and emphasizes that no amount of crisis management planning can eliminate the need for subjective judgement and ad hoc decisions.

Through the media, the public has become acutely aware of [illegible] and the threshold for tolerating spectacular assaults has risen [illegible] novelty of terrorism wears off. Given that the terrorist's [illegible] disruption and shock, then it may be speculated that terr[illegible] organizations will change their tactics and their targets [illegible] retain traumatic impacts and stay ahead of government [illegible] terrorism preparations. Terrorists are resorting [illegible] pistols, submachine guns, and bombs; attempts [illegible] surface-to-air rockets and Soviet-made ant[illegible] Terrorists have threatened to disperse [illegible] and in one incident, a radioisotope [illegible] train. Attacks have been made on [illegible] studios, and nuclear power plants [illegible] diminishes, merely increasing [illegible] point. A shift to econom[illegible] likely to occur. Targets [illegible] systems, commer[illegible] obvious. However, [illegible] are [illegible]

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Additionally, if terrorists make the maximum threat and fail to achieve their objectives, the need to rely on subsequent, lesser threats would undermine their credibility.

Companies frequently face the threat of kidnapping. Direct losses due to the payment of ransom are only part of the economic implications; associated policy and legal questions are likely to confront uninformed corporations that have paid ransoms. Stockholder lawsuits may contest the wisdom of ransom decisions; paying ransom is illegal in some countries and may jeopardize the company and its officials. The families of kidnap victims may seek legal recourse if they feel that the victims were inadequately protected or that the company erred in decision making. If a company facing a known threat has not taken reasonable security and other preparedness measures, it may face uncharted and expensive areas of negligence. If, for example, a terrorist threat can be predicted against a utility, that utility has the responsibility to take precautions to prevent the threat from succeeding. If it does not, the liability of the utility is unclear and may not end with the temporary loss of business and restoration costs but extend as well to resulting business losses throughout the community. The effects of terrorism on morale must also be considered. Adverse effects include the daily stress to threatened employees and difficulty in attracting top-quality prospective employees for assignments in unstable areas.

International agreements, thoughtful government and industrial planning, the creative use of technology, and well-thought-out negotiating tactics are the tools with which governments and industry can control terrorism. Counterterrorism may be divided into four functional tasks: (1) prevention--denying access to suitable targets and protecting targets if an attempt is made; (2) control--establishing mechanisms for command and control of government and private resources to assure efficient response to an incident; (3) containment--taking measures to limit the terrorist act physically and divorce it from the intended political consequences psychologically, which includes actions to limit damage and provide emergency health care; and (4) restoration--taking deliberate actions to conclude the incident and restore normalcy. When measuring the value of various physical security systems against the projected threat, it is important to survey available technology and perform sophisticated cost-effectiveness analyses. Crisis management techniques are also essential, such as the development of relevant management information systems, methods to test threat credibility and assess damage rapidly, and bargaining strategies designed to minimize the cost of extortion. Industry and government must work together, although industry might focus primarily on damage limitation while government emphasizes deterrence.

Given possible attack scenarios, analyses of the cost-effectiveness of physical methods of protection can be made, incorporating the costs and values of critical assets. Protective measures include sensors; access control systems; and command, control, and containment systems. Additionally, the vulnerability of critical targets should be evaluated in relation to the countermeasures available. Innovative methods of analysis, such as fault-free techniques, should be employed. In some cases, trade-offs may favor disproportionately high investments in hardening key nodes, even though a terrorist attack may be considered improbable. If intelligence and physical security systems fail, the next recourse may be the efficient management of the crisis itself. In crisis management, a thorough analysis of gaming, training, management information, and organizational needs is extremely important. However, overly complex training and management systems should be avoided when dealing with the more usual incidents, such as kidnapping. In summary, industry must take obvious security precautions, protect its people, cooperate with governments, and expect to manage unpleasant crises.

The article is very informative in detailing the implications of terrorist threat for the commercial and industrial sectors. An editorial note states that the views are those of the author and are not reflective of the U.S. government or any of its agencies or departments.

73

Kutchins, Kay. 1978. Plan for an Emergency Before It Happens. Journal of the American Water Works Association 70:308-310.

The article provides a basic framework for the development of an emergency operations plan by a water utility.

A guideline for preparing an emergency operations plan is offered that includes a schematic diagram of steps in emergency planning. The four water subsystems to be considered are collection, transmission, treatment, and distribution. Within each subsystem, the components to be considered include power, accessibility, personnel, materials and supplies, communications, equipment, and structures. Steps in emergency planning are: (1) hypothesize the emergency and (2) assess the system's vulnerabilities. This knowledge is used to arrive at an overall system operational ratio. A Texas emergency planning committee developed a mathematical model in which numerical values are assigned to response capability of various components in the system. These numerical ratings range from 0.1 (10 percent operational) to 0.9 (90 percent operational). This approach provides a blueprint for improvement of weak areas as well as concrete data to aid the utility in seeking funds for additional staff, supplies, or equipment to strengthen emergency capabilities. A third step is the determination of the types of demands to be put on the system and the quantities needed for each. The final step is the establishment of priorities in the use of resources--who gets service restored first, what will be repaired first, how remaining capabilities will be allocated throughout the emergency. The priorities for return to service, the program for best use of available resources, and the matching of tasks with personnel form the basis of a written emergency operations plan, which should be reviewed and updated each year.

The article effectively illustrates the necessity of emergency operations planning for every water utility and provides concise information for the formulation of such plans.

74
Lacy, William J. 1963. Methods of Radioactivity Removal. Journal of the American Water Works Association 55:1249-1252.

This paper describes the efficiency of the removal of radioactive materials in conventional water treatment processes such as coagulation, sedimentation, filtration, lime-soda ash softening, and ion exchange.

The bulk of contamination with insoluble radioactive fallout particles can be easily removed by coagulation with settling. About 75 percent of nuclides can be removed in this process. Softening with lime and soda ash can result in removals of fallout debris (including dissolved matter) greater than 99 percent. Ion-exchange resin used as a slurry in pretreatment can remove more than 98 percent of the dissolved radioactive contaminants. Home water softeners have also been found to revise 97 percent of radioactive materials. The most effective process presently available for concentrating radioactive contaminants is distillation; however, this method can be used only for small volumes of water.

Overall, the article is somewhat dated and does not contain original empirical data. The usefulness of some processes for the removal of chemical-biologic-radioactive contaminants seems to be based on the professional judgment of the author.

75
Lambright, W. H. 1984. Role of States in Earthquake and Natural Hazard Innovation at the Local Level: A Decision-Making Study. Syracuse Research Corporation. Washington, D.C.: The National Science Foundation.

This study compares and contrasts the process of policy development and innovation in earthquake preparedness at the state level among three different policy settings--emergent, intermediate, and advanced. The authors provide illustrative case studies.

A given policy innovation process begins with an awareness by an individual or group of a major problem or opportunity requiring governmental action. A trigger is required; a stimulus to move awareness to policy action of some kind, so that a process of search/ planning for an appropriate response begins to unfold. Then, an option for policy is proposed for adoption by government. If adopted, a policy must be implemented, becoming a program which is assigned to an organization or becoming the base around which an organization is formed. Finally, there is incorporation, the end of implementation, when a program is completed and ceases to be innovative.

There are certain basic roles involved in any innovation policy. The developer is the organization that creates the innovation. The users are those who are the clients of the new products and processes that are created. Sponsors pay for the development; they are often external to developers and users. Opponents do not want the innovation or require that it be modified to be more acceptable. Beneficiaries may not actually participate in a given decision, but they are affected by decisions and can influence them indirectly by their attitudes. The role most critical to the innovation process is that of the entrepreneur, the moving force, who creates change through political coalition building.

South Carolina and Nevada are examined as emergent settings in which earthquake preparedness is a low priority from the perspective of public awareness or political support. Entrepreneurship becomes more evident and viable with the intermediate earthquake policy system of California. A large part of the study focuses on providing a detailed account of the Southern California Earthquake Preparedness Program (SCEPP), which the author regards as one of the most significant institutional innovations to take place in earthquake preparedness policy in many years. The advanced policy setting of Japan represents not only preparedness but also earthquake prediction activity, a permanently established national and regional political leadership, and public awareness programs. The author points to the creditability of the earthquake threat as the primary distinguishing factor; the experience of the tragic consequences of an earthquake and the ability to predict the likelihood of a near-term potential occurrence provides the impetus for evolution to an advanced policy setting.

The study provides a detailed account of the successes and failures of each of the three policy settings, delineating lessons learned in each of the three case studies.

76

Lang, William G. 1984. When Opportunity Knocks--Security Planning for a New Facility. Security Management 28(5):60-64.

The author emphasizes the importance of including security system needs in the planning of a new facility and offers recommendations for integrating security considerations into the planning process.

The lack of security planning for new facilities is a common problem. Although mandatory fire alarm systems are usually included in planning specifications, attention may not be given to budgeting for a full security system to protect company assets or, in the case of companies contracting with the Department of Defense, to meet DoD standards. The security manager should meet with key planning people to determine how funds are to be allocated. If a single capital expenditure is to be established for the entire job, the security manager should immediately provide an estimate that includes the entire security system. If construction costs and fitting costs are to be separated, the construction estimate for security funding may include only the fire alarm/evacuation system, with all other security costs to be included in the fittings budget. In planning a system, the security manager should take into consideration the architect, the initial floor plans, the size and layout of the facility, facility operations, the number and location of occupants, and the locations of senior company staff. The local police department can provide information on the extent of criminal activity and patrol coverage in the area as well as expected traffic condition

The author provides a step-by-step guide for evaluating security needs, revising plans throughout the design and construction periods, and estimating expenditures. Recommendations are given for ordering equipment; overseeing the shipment process; installing security systems; and ensuring a safe, secure move when the new facility is occupied. Special emphasis is given to the training of security personnel in relationship to the new facility.

This article contains an in-depth examination of the processes involved in assessing the security needs of a proposed facility, integrating security considerations into the overall planning effort, and implementing the new security system. This information would be very useful to utility managers in the planning of new or expanded facilities.

77

Langowski, J. F.; L. E. Lang; J. T. Bandy; and E. D. Smith. 1985. A Survey of Water Demand Forecasting Procedures on Fixed Army Installations. Technical Report N-85/07, U.S. Army Corps of Engineers Construction Engineering Research Laboratory.

This report documents research conducted to (1) determine the nature and type of water-planning activities practiced by installation water utility managers; (2) evaluate current Army procedures for estimating average daily water demand; (3) formulate a procedure to determine which Army installations should be considered for a water use survey; and (4) determine the adequacy of contingency plans required by Army regulations.

A survey was conducted in which 85 installations responded to questions directed to installation water utility managers to determine if emergency water contingency plans were on hand. Contingency plans included drought, contaminated water quality, breaks in transmission or distribution lines, water plant interruptions, emergency mobilization requirements, or combinations of these types. Fifty-one installations (60 percent) indicated that no documented emergency water contingency plans were on hand. Among the 34 installations (40 percent) having a written contingency plan, the water emergency most frequently receiving planning attention was drought (18 plans), followed by contingencies to engage emergency mobilization water needs (14 plans). Currently, 55 installations (64 percent) indicated that they had not implemented a water conservation program in the past five years, which may further indicate deficiencies in mitigating actions to reduce the impact of water-related emergencies or disasters.

78
Larkin, D. G. 1969. Readiness for Earthquake--Seisimicity Studies. Journal of the American Water Works Association 61:405-408.

The author reports on a seismic survey of the East Bay Municipal Utility District water transmission system to determine its vulnerability to earthquakes. According to scientific data one major earthquake is expected to occur in the area every 60 to 100 years and twelve damaging earthquakes every 100 years.

In 1969, EBMUD served 1,100,000 people living within a 275 sq. mi. area in Alameda and Contra Costa counties. About 80 percent of water is delivered to the area via the Mokelumme Aqueduct System comprised of a source reservoir, three 100 mile-long aqueducts, and five terminal reservoirs. Raw water is treated in seven filter plants and 3.5-mi., 9-ft tunnel and three 54-in transmission aqueducts deliver water to 100 pressure zones of the 3,100 mi of pipe distribution system. These zones are supplied by 150 tanks and reservoirs and 90 pumping plants.

The parts of the system subject to different seismic forces include (1) facilities located at Hayward Fault Zone including the Claremont Tunnel, the San Pablo raw-water tunnel, the Sequoia Aqueduct, and many smaller pipelines, pumping plants, and reservoirs; (2) three Mokelumme Aqueducts crossing the Franklin-Sunol Fault in Walnut Creek; (4) distribution mains in Tidelands or alluvial fill areas; and (5) pipelines in hill areas subject to sliding.

Planning and design standards adopted by EBMUD to minimize system's damages due to seismic forces include (1) consideration of lateral seismic forces of 0.15G (15 percent of dead weight) as a design standard for various structures; (2) sizing distribution system storage reservoirs at two times maximum-day demand to provide an emergency supply; (3) maintenance of 90 days' supply in the five terminal reservoirs in case of failure of the Mokelumme Aqueduct System; (4) redesign of pipelines in fault zone to include aboveground installation of conducts, flexible joints, double-welded joints, and additional values; and (5) strengthening of the 9-ft horseshoe Claremont Tunnel at the Hayward Fault by placing steel bents against the concrete lining.

Other planning and design elements that pertain to seismic emergency include (1) installation of raw-water bypasses of all filter plants equipped with standby chlorination facilities; (2) addition of a 250-kw generator to the existing 100-kw portable unit to operate most of the distribution system pumping plants during earthquake emergency; (3) instrumentation of flow on major distribution system using telemetry equipment; (4) stockpiling of a maximum possible number of 1-ton chlorine tanks and a good supply of hypochlorite for main disinfection; and (5) adoption of other standard operating rules and procedures in order to provide maximum readiness in case of earthquake.

The EBMUD sees its major role in an earthquake emergency as the provision of water to fight fires. Many of the plans made or practices adopted consider this goal.

79

Lindsten, Don C. 1978. Decontamination of Water Containing Chemical Warfare Agents. Journal of the American Water Works Association 70:90-92.

The article analyzes the possible dangers of chemical warfare agents in water supplies and details possible methods for detecting and eliminating their presence. The author reviews current and historical aspects of chemical warfare.

Chemical warfare (CW) is defined as "the intentional use of toxic gases, liquids, or solids to produce casualties or degrade combat effectiveness." The author provides a list of historical milestones in chemical warfare and notes that chemical weapons are tactical weapons that can travel around corners, diffuse throughout space, and seep into structures. Their physiological effects range from mild temporary narcosis to severe bodily damage and death. They are for the most part colorless, odorless, and tasteless, with their first indication often being the appearance of casualties. Most CW agents are relatively easy to produce in large quantities at moderate cost.

Nerve agents are the greatest single water contamination threat. Blister agents, arsenicals, and blood agents are much less so. The presence of CW agents in water can be determined by the use of detection kits. Additionally, certain signals may be indicative of CW contamination: (1) dead fish or other aquatic life, including vegetation; (2) unusual odor from the water, perhaps characteristic of certain CW agents; (3) an unusually high chlorine demand; and (4) intelligence indicating either a general CW attack or sabotage of the water supply. The U.S. Army would be called on to decontaminate water containing CW agents.

Although the standard army ERDLator water-purification unit is ineffective when used directly against most CW agents, it is the apparatus of choice for clarification and disinfection of polluted fresh water. It was decided to develop a pretreament set to remove, inactivate, or destroy all CW agents prior to processing in the standard ERDLator. The pretreatment procedure consists of superchlorination with 70 percent strength calcium hypochlorite to 100 mg/l (ppm) available chlorine followed by a dechlorination with 600 mg/l (ppm) of activated carbon. When tested, the CW Pretreatment Set, in conjunction with the ERDLator, reduced contamination to maximum permissible concentrations (MPC) in most instances. Where MPC is not achieved, a second pretreatment can be used. Additional decontamination procedures include distillation of water containing certain CW agents and reverse osmosis, which is under investigation for use as an all-purpose water detoxification unit. In testing, reverse osmosis achieved MPC in only one instance, but the product water was excellent in all other respects and a posttreatment polish to remove the remaining traces of CW agents could be used. The author notes that personnel protection is imperative when operating water-purification equipment on raw water containing CW agents and describes protective clothing requirements.

The article offers an informative introduction to the subject.

80

Louis, Leo, and Charles A. Froman, Jr. 1973. Planning & Training--Key to Effective Operations during a Strike. Journal of the American Water Works Association 65:326-330.

The purpose of the paper is to illustrate methods of preparing for labor strikes through emergency planning and employee training efforts. The authors present details of a strike against the Gary-Hobart water utility in Indiana as an illustrative example.

The Gary-Hobart Water Corporation was struck by its operating and construction employees between June 1 and August 29, 1971. Supervisory personnel carried out vital operational functions, and the suspension of operations was never required. At the time of the strike, Gary-Hobart was an investor-owned utility serving 250,000 people in northwestern Indiana. In addition to the approximately 100 production, maintenance, and construction employees whose union was directly involved, 34 of the 40 clerical workers represented by the same international union engaged in a sympathy strike. Thirty-one supervisory employees and 26 nonstriking employees provided services throughout. On the first day of the strike, an Indiana Chamber of Commerce booklet, "Management and Strikes," was very useful in delineating the rights of the employer, the responsibilities of the police, and the applicable laws. Three weeks into the strike, and after repeated written warnings, the sympathetic clerical workers were discharged for their refusal to come to work. Subsequently, the discharged clerical workers joined the picket lines and incidents at the line increased, resulting in the arrest of several pickets on June 23. A court agreement was obtained to limit picketing and assure freedom of movement by employees. Although there were incidents of harassment and vandalism throughout the strike, most occurrences were minor and service remained uninterrupted. The strike ended after three months.

Strike planning and employee training were significant factors in the uninterrupted provision of services. Planning and training for strikes should include continuous, long-range efforts as well as the intensive, short-range efforts implemented in the face of a strike. Long-range activities include training of key management personnel in labor relations and contract negotiation. Seminars in these areas are frequently offered, and informative publications are readily available. Care should be taken in structuring the supervisory staff so that a balance is achieved between supervisors who have progressed through the ranks and have a working knowledge of company operations and those who entered directly into supervisory positions. The knowledge and skills gained through previous work experience have proved to be invaluable in allowing supervisory staff to continue the provision of services in the event of a severe personnel shortage. A good public relations program and the coordination of utility activities with local municipal organizations are long-range efforts that should be maintained on a continual basis. It is very important to retain the services of an attorney skilled in labor law; a preexisting working relationship will greatly enhance an attorney's ability to perform if problems arise. Short-range activities must be conducted within a few months of an impending strike. These efforts include the assignment of employees to specific responsibilities, the development of emergency work schedules, and the training of emergency personnel in their newly assigned duties.

Security needs present special problems during strikes. Strike planning should incorporate the escalation of risk, and security measures should be adjusted accordingly. Measures taken by Gary-Hobart include (1) a contract with Pinkerton, Inc. to provide roving patrols in unmarked cars; (2) uniform guards stationed at the main treatment plant and distribution center around the clock; (3) conferences with various police agencies to alert them to potential problems; and (4) the changing of locks at gates and buildings where keys had been widely distributed before the strike. Provisions were made with a local contractor to change the locks on the day before the strike was to begin. It is useful to have locks made so that cylinders can be removed and rekeyed or replaced. It is important to have photographic documentation of incidents occurring during a strike; both movies and still photos are desirable as documentary evidence.

If outside contractors are to be obtained, care should be taken to weigh the benefits of additional services against the friction with the union that might result. If contractors are to be utilized, it is preferable to have a working relationship with them prior to the strike so that they might be less vulnerable to pressures from the striking union. Supervisory personnel should be provided with company vehicles to reduce the risk of damage to their personal cars. Whenever possible, maintenance work should be checked and completed prior to a strike to avoid the drain on a limited emergency staff. Cots, bedding, and food supplies should be stored at key locations. Up-to-date directories of support personnel and outside agencies should be available to each employee. Prearrangements should be made with the telephone company to switch managers' home phones to unlisted numbers if crank call harassment occurs. A maximum inventory of necessary chemicals and materials should be collected prior to a strike to reduce the risk of shortfalls during the emergency period.

The article is very informative and offers useful guidelines for strike contingency planning and preparation.

81

Lovejoy, G. Montgomery. 1983. Water Management Initiatives in the Commonwealth. WATER/Engineering and Management 130(3):30-32.

This article describes a comprehensive water management and protection bond program in the state of Massachusetts.

Although Massachusetts enjoys substantial average annual precipitation, parts of the state have experienced crisis water levels due to past mismanagement of water resources. Recent state legislation provides for cleanup and protection of water sources and public systems by providing matching funds to community applicants with completed or in-progress comprehensive water management programs.

Fourteen of the state's 350 cities or towns have declared water emergencies. State regulations require the declaring community to obtain "Chapter 40 approval" that allows the city or town to enlist the courts to enforce water restrictions necessary to protect public health and safety. Priority water uses are for drinking and fire protection, not manufacturing. As an alternative to "Chapter 40 approval," communities may formally adopt rules and regulations (emergency water plans) to be implemented by town officials during an emergency. The latter course of action is stated as the preferred option because it adds an element of certainty and preparedness which otherwise would not exist. Additionally, manufacturing firms are urged to participate in the emergency water plan formulation.

Water-pricing trends in Massachusetts and industrial water conservation initiatives to reduce cost increases are also presented in this paper. Manufacturing water use reduction measures are suggested to preclude or mitigate the impacts of a potential water shortage.

The article is concise and informative and could be useful to emergency water supply planners at the local or state level.

82
Lowe, John S.; Lon C. Reudisili; and Bruce N. Graham. 1979. Beyond Section 858: A Proposed Ground-Water Liability and Management System for the Eastern United States. Ecology Law Quarterly 8:131-161.

This paper presents a proposal that would bring eastern states the presently lacking statuatory authority to control groundwater use in the event of a shortage or degradation. The paper traces the evolution of common law pertaining to groundwater rights of landowners from the English rule of absolute ownership, to the American rule of reasonable use, then to the Second restatement of Tort's modification of the American rule, commonly referred to as Section 858.

The Restatement formulation stipulates that a landowner is not liable for interference with another user by withdrawing water for a beneficial purpose, unless the withdrawal causes unreasonable harm, exceeds the proprietor's reasonable share of the annual supply, or has an adverse effect on a lake or water course and unreasonably causes harm to entitled use of the water.

The authors criticize Section 858 in that it (1) fails to consider water shortages; (2) lacks certainty or predictability as a code of conduct that permits society to structure their actions to avoid disputes; and (3) fails to provide a basis for the management of groundwater resources in the public interest. In their proposed solution, the writers suggest (1) tailoring the western system of prior appropriation to meet eastern conditions; (2) establishing a general rule of liability for noncritical groundwater areas through application of a first user principle, a priority use rule, or a comparative cause rule; and (3) protection of critical ground water areas by new state groundwater management laws which would provide for the designation and regulation of critical groundwater control areas.

This paper effectively describes the potential legal dilemmas facing governmental units which desire to use existing groundwater supplies to serve the public interest during water shortage situations.

83
Mackay, Donald. 1985. The Role of Computers in Chemical Spill Response. Paper presented, Environment Canada Annual Technical Chemical Spills Seminar. Canada: University of Toronto.

The author speculates on the role of computers in chemical spill response efforts by presenting a hypothetical chemical spill scenario. The article addresses current computer capabilities as well as those projected for future applications.

The scenario is that of an overturned tank truck near an icy highway in February in the early morning hours. The tank is punctured and begins to leak, creating a pool of liquid and a cloud of vapor. Upon the notification of authorities, the immediate area is evacuated, and the local fire chief arrives at the site carrying her portable computer, a printer, software, and a radio to initiate emergency response proceedings. She establishes a radio link with the National Spill Response Center and brings up a computer program to identify the spilled material. The identification program identifies the material as vinyl chloride and instructs the user to initiate a chemical properties program. The properties program yields a printout with information on the nature of the chemical, its likely behavior, and necessary precautions. The properties program contains the contents of the entire Environment Canada Technical Information for Problem Spills (TIPS) manual.

A SPILL program determines the type of spill, its volume, area of spread, and depth, and calculates the spill's behavior. An EVAPORATION AIR DISPERSION program gives estimated concentrations at various distances downwind to help identify inhalation hazards. A SOIL PENETRATION BEHAVIOR program indicates that there is little danger of contamination of the water table. Early morning rains bring the threat of contamination of a nearby creek; the fire chief uses an AQUATIC SPILL program to determine the chemical's behavior in water. A GENERAL ENVIRONMENTAL FATE program reveals where the chemical is likely to go, how long it will persist, which areas are of greatest concern, and which areas will remain unaffected. When the leakage stops, a COUNTERMEASURES program indicates that the tank may be patched and moved to a safe site for transferal of the remaining material.

The author notes that all of the computer services detailed within the scenario are feasible; many already exist, and others could be developed within the coming decade. Requirements and benefits of such programs include (1) a portable computer can store an enormous amount of factual information that would be unwieldy if maintained in paper text form; (2) on-scene personnel can be supplied with data from their own disks and from a mainframe computer linked by telephone or radio to the spill site; (3) on-scene personnel must be thoroughly acquainted with the programs and be confident in their use; (4) response programs may be run in parallel at spill response centers so that experts can advise and double-check all procedures; (5) programs must be relatively simple, very robust, and require only essential data, even if it means developing several versions of increasing complexity; and (6) there is no substitute for informed human judgment and ingenuity--the computer is only a tool.

The article provides an interesting view of the potential for computer use in emergency response procedures.

84

MacLeod, D. C. 1982. Security in Water Supply: Some Experiences from Durban, South Africa. Paper presented, International Water Supply Congress and Exhibition. Denver: American Water Works Association.

The author describes efforts to increase the assurance of safe drinking water by the municipality of Durban. These efforts include the installation of a telemetry system, increased protection of aqueducts, and increased protection against back siphonage and contamination.

Accidental pollution resulting from the failure of a treatment plant may occur from overdosing or underdosing of chemicals. Durban has installed measuring cell assemblies to measure chlorine residuals, and chlorine residual indicator transmitters, all of which have been set to signal alarms at inappropriate levels. The alarms are conveyed by a telemetric system to a central recording station, which also controls the disinfection dosage facilities at outlying service reservoirs. Further monitoring systems are being installed to assist in the detection of intruders at sensitive areas within the water supply system.

Raw water is conveyed from the dams to the treatment plant by gravity. The country through which the aqueducts pass is very rugged, and many of the gullies and local depressions are crossed by pipelines supported by concrete piers. Flash floods have repeatedly undermined the supports, necessitating emergency repairs. Additionally, elevated crossings may become a likely target for terrorist attacks. The municipality has begun a program to replace the elevated crossings in flexible piping by underground or above-ground continuous welded steel piping. Development along aqueduct routes must be continuously monitored. In 1976, a major storm resulted in the collapse of a private swimming pool, which washed away a hillside in which two major pipelines were laid. Due to the interruption in supply, major industries were forced to shut down for ten days.

Durban has long relied upon the requirement that an air gap exist wherever back siphonage might occur, yet several failures to observe this practice have resulted in contamination of the water supply system. In one case, three men were hospitalized following the contamination of drinking water supplies by factory cooling water containing 12 ppm chromate as well as oil dispersants. The increase in the installation of pop-up sprinklers increases the need for positive back-siphonage controls. Water supply managment in Durban has turned to commercially available backflow prevention valves to alleviate the threat of accidental contamination. The author notes the importance of clearly identifying water mains where multiple piped services are accommodated within a single area to avoid unfortunate cross-connection incidents.

In many cases, the public has become accustomed to the continuous provision of good quality drinking water and responds unfavorably to possibilities of interruptions in supply. The author notes a need for public education to facilitate the acceptance of situations in which minimal drinking water needs may be met only by the provision of water tank trucks. In many cases, the need to balance the demands of the domestic consumer against those of industry and water-sensitive consumers (e.g., hospitals) may result in the adoption of high-maintenance water security measures in an effort to forestall water emergencies.

The article provides useful information on the adoption of water security measures.

85
Manwaring, James F.; Lowell A. Van Den Berg; and Barbara Faust. 1980. EPA Puts Emergency Water Provisions into Action. Water & Wastes Engineering 48:40-44.

The case study of the spills of tetrachloride (CCL_4), a suspected carcinogen, in the Ohio and Kanawha rivers is described together with the assessment of the appropriateness of the EPA involvement in the corrective action and its future role in similar incidents.

In April, 1975, the data from the EPA's National Organics Reconnaissance Survey showed a CCL_4 level of three to four parts per billion (ppb) in the drinking water supply of Huntington, West Virginia. The follow-up samples collected during the summer of 1975 and in March, 1976, failed to show detectable levels of CCL_4. However, on September 29, 1976, the samples collected at Huntington showed CCL_4 levels of 10 ppb. As a result, inquiries pursuant to Section 308 of the Federal Water Pollution Control Act (FWPCA) were sent to the four major dischargers of CCL_4 in the Ohio basin upstream from Huntington. All four dischargers were asked to participate in a 45-day self-monitoring survey of their effluents which could lead to the inclusion of a CCL_4 limitation in the National Pollutant Discharge Elimination System (NPDES) permits required under Section 402 of FWPCA for the respective industries. Legal action was required of the U.S. attorney general due to the refusal of one company (Company A) to participate.

At the beginning of February, 1977, the levels of CCL_4 in Cincinnati's tap water were found to exceed 80 ppb. The samples collected from the Ohio River and its tributaries revealed that a 70-ton slug of CCL_4 was present in the river upstream into the Kanawha River. An earlier sampling conducted by the National Organics Monitoring Survey (NOMS) showed a CCL_4 concentration of 50 ppb in the Huntington drinking water on January 26, 1977. Following these incidents, EPA learned that Company A had reported about 20 CCL_4 spills to the state in the past two years. The EPA and the U.S. attorney general asked the federal district court in Huntington to issue a temporary restraining order under the emergency provisions of Section 1431 of the Safe Drinking Water Act and Section 504 of FWPCA.

EPA had made an error in predicting the time of travel of the 70-ton slug of CCL_4, which resulted in imprecise warnings sent to public water systems upstream of Cincinnati. This experience demonstrated the need for the EPA to interface with the news media, the public, and water suppliers and to improve its procedures for collecting data and evidence for possible enforcement of the applicable federal regulations. Other recommendations resulting from this experience include (1) development of a systematic monitoring and control program; (2) formalization of the current procedure for issuing guidance on the safe levels of various compounds in drinking water; (3) one-person coordination of all future emergency situations; (4) mobilization of several sections of the agency (e.g., water supply, enforcement, surveillance, and analysis) to deal with hazardous contamination incidents; (5) development of an accurate hydraulic model for Ohio and Kanawha rivers for predicting arrival time of pollution slugs at downstream points; (6) consideration of the potential impacts of microtoxicants on downstream users in the reissuance of all NPDES permits for discharges; and (7) development of a formal contingency plan for the agency to deal with the spills of toxic substances.

86

Marcello, Thomas J. 1978. Emergency Procedures. Journal of the New England Water Works Association 112:317-328.

The purpose of the paper is to review four basic emergency procedures developed by the Water Bureau of the Hartford Metropolitan District of Connecticut (Hartford MDC). The four procedures are civil preparedness, fire, oil and chemical spills, and plant emergencies.

An emergency is defined as an unforeseen combination of circumstances or the resulting state that calls for immediate action. An emergency procedure is defined as a plan that is used to effectively respond to an unforeseen event. The Hartford MDC has a comprehensive emergency operations plan which was formally put into effect in 1973 and coordinates efforts with the state of Connecticut Office of Civil Preparedness. The primary goal of the plan is to provide water and sewerage services during human-induced or natural disasters. A formal structure of organization and communication between MDC internal departments and outside agencies was created, and an Emergency Operations Center established. There are two phases of implementation, an Increased Readiness Phase and an Emergency Phase. During the Increased Readiness Phase, all MDC department heads and support personnel are briefed on the impending emergency, employee assignments are reviewed, and supplies and equipment are checked. If necessary, the district manager declares a state of emergency and the Emergency Phase begins, in which district support forces are alerted, the Emergency Operations Center is activated, and the formal line of communications is established. The Emergency Operations Center houses an extensive array of internal and external communications equipment and emergency supplies.

The MDC fire plan consists of three elements: prevention, drills, and emergency action. Routine monthly inspections of all MDC facilities are conducted and the responsibility for follow-up corrections is delegated to specific employees. A fire drill is held at least once every six months, and fire extinguishers are actually operated by employees during the drills. During an emergency action, personnel are assigned specific duties relating to fire fighting, to protection of documents and property, or to assisting the fire department.

Although the state Department of Environmental Protection is responsible for coordinating hazardous materials cleanup, water utilities are prepared to respond in the event that there is a delayed response by the primary authorities. The author provides references for the development of a hazardous materials spill contingency plan.

The three major elements of the Plant Emergencies section of the emergency operations plan are chlorine leaks, main leaks, and electrical outages. A list of precautions and a detailed chlorine emergency plan are described. Main-break emergency plans involve preventive maintainance of gate valves, operating all gate valves yearly to the position opposite from their normal usage, and regularly reviewing the location of the most critical valves. The use of gate books and logs to record valve activity is emphasized. Emergency generators are operated monthly by operators on each shift, and battery chargers are checked routinely.

The article is informative and offers useful guidelines to the formulation of particular sections of a water utility contingency plan.

87
McCann, John P. 1985. How to Prepare for an Earthquake: A Guide for Businesses. New York: Insurance Information Institute.

This publication presents detailed guidelines to assist businesses in earthquake preparedness planning. Appendixes contain background information on planning resources, significant U.S. earthquakes, U.S. seismic risk mapping, and potential effects of earthquakes.

Businesses with extensive preparedness plans have identified several important elements: (1) the employment of a structural, civil, or other engineer to assess the office/building's vulnerability to seismic damage and to offer recommendations for improving earthquake resistance; (2) the establishment of an alternative communications link between the office and homes of key employees; (3) the maintenance of an earthquake preparedness plan that has been drilled and tested; and (4) the consideration of the possibility of being marooned in an office for an extended period of time. The author notes that a business does not have to be in the impact area of an earthquake to be affected by it. Primary buyers or suppliers may be lost and certain resources may become scarce and costly. The value of stocks and bonds of corporations and public utilities in the damaged area might be affected. It is especially important that businesses consider their legal liabilities in terms of protecting employees, jobs, and company profits.

Five categories of preparedness guidelines are given: (1) protecting employees at the office, including office conditions, emergency directions, management procedures, evacuation procedures, consideration of persons with disabilities, fire prevention equipment, shelter, medical supplies, food and other supplies, employee personal instructions, family communications, and nonemployee policy; (2) protecting employees at home, including preearthquake measures, emergency supplies, a readiness checklist, emergency procedures, and disaster recovery; (3) protecting office/computer facilities, including location of facilities, computer equipment, and miscellaneous facilities; (4) protecting operations, including management continuity, emergency staffing plans, vital records maintenance, data processing, insurance claims handling, public information, transportation, communications, building security, and data gathering; and (5) protecting company assets, including insurance coverage, reinsurance, mortgages, and investments.

This publication offers valuable, detailed information on earthquake preparedness planning for businesses. These specific guidelines could be extremely useful to utility managers in estimating and strengthening the vulnerability of personnel and administrative components, not only for earthquake hazards but for other disasters as well.

88
Melvold, R.; S. Gibson; R. Scarberry; W. Ellis; and M. Royer. Development of a Guidance Manual for the Selection and Use of Sorbents for Liquid Hazardous Substance Releases.

The purpose of this study was to provide information and data for the selection, acquisition, application, collection, regeneration, and disposal of sorbents for cleanup or control of liquid hazardous substances.

The final product of this study would be in the form of a guidance manual for the selection and use of sorbents for liquid hazardous substance releases. The manual will enable the user to quickly locate pertinent sorbent information (mainly sorbent type and its sorption capacity) by providing a chemical index organized by chemical name and DOT number, which is cross-referenced to "Sorbent Selection and Use Guides" and "Sorbent Data Sheets." The manual includes 190 sorption capacity measurements of representative sorbent/hazardous liquid pairs. The sorption capacity data are given in grams of hazardous liquid per gram of sorbent.

The primary target audience for the manual is federal on-scene coordinators and their technical support staffs.

99

Midwest Research Institute. 1979. Earthquake Risk and Damage Functions: An Integrated Preparedness and Planning Model Applied to New Madrid. Washington, D.C.: National Science Foundation.

This study attempts to develop a comprehensive understanding of the social and economic consequences of possibly damaging earthquakes in the New Madrid Seismic Zone. The objectives include the development of a simulation model so that various physical damage functions can be empirically estimated, then converted into economic damage values. A third essential component of the study is an examination of the institutional aspects related to government and community preparedness and response.

Both probabilistic and deterministic approaches were utilized in the earthquake risk analysis. In determinining the physical damage functions for different types of earthquake risk receptors (populations at risk), especially for structural damages, the surface materials and ground conditions were studied. The 15-county study region was reclassified into six major categories of vulnerability. The vulnerability indexes developed were utilized as the weight factors in the physical damage function. Three categories of populations subject to earthquake risk were identified: (1) human populations (diurnal and nocturnal), (2) structures, and (3) personal property. The basic data unit was a census tract, and the aggregate level of estimation of population at risk was a county. For structural populations both the market value as assessed by county assessors and the replacement cost of new construction estimated by a structural engineer were employed to illustrate range variation.

In the development of physical damage functions, econometric techniques of linear and log-linear regressions were employed to estimate the functional relationship between physical earthquake damages, the damage ratios, and the Modified Mercalli intensity of various earthquakes occurring in the United States. This was done in conjunction with exogenous determinants such as population density, distribution of the structures, the type of construction material, and age of the structures. A recursive model of structural damage, property damage, and human mortality and injury was constructed to illustrate the interdependent relationships among these risk receptors. Base-line data and the projected values of populations were fitted to the model to simulate quantitatively the potential damage of various earthquake risks that the study region will face from 1980 to 2030 with virtually no additional hazard mitigation action or risk reduction program implementation.

A thorough discussion of results for the New Madrid Zone is offered but not summarized herein. The researchers note that the damage results estimated in their study are much smaller than those of other investigations; conservative estimates are useful as base-line information, and the reduction of damage estimates may reflect increasing seismic awareness and adaptation. Recommendations are made that the physical damage functions be further refined and disaggregated, and that additional research be directed toward finer risk population estimation.

90

Murzycki, John V. 1983. How to Break Bad News to the Public. Journal of the New England Water Works Association 97:239-245.

The article underscores the importance of effective public relations in the successful resolution of an emergency situation. The author reviews guidelines for the development of emergency public relations plans.

The presentation of unpleasant news or emergency situations to the press and to the public can affect a utility's credibility with the media, the public, employee morale, and the future of the organization. Although the initial reaction is frequently that of debating the need for disclosure, a candid treatment of the situation is the only viable solution. Although stonewalling the issue is unacceptable, a hasty, unprepared response may be just as damaging to credibility. The best approach is to prepare in advance for emergency public relations by organizing a communications team that agrees on the content and manner of public communications. Persons designated to speak on behalf of the company should be available to the press at all times and have accurate, up-to-date information about a given situation. It is frequently beneficial to be aggressive with the media by contacting them with the facts before they learn of the situation for themselves. Constructive preparations include the investigation of steps to prevent or reduce a crisis, the establishment of contingency measures to be activated when a crisis occurs, and the formulation of a follow-up program to reestablish the utility's standing after the crisis is over.

Once potential emergencies have been identified and all possible steps taken to mitigate their effects, the public relations plan should be prepared. Decisions regarding each crisis include notification of utility personnel; selection of a media contact person within the company; determining the format of news releases, e.g., press conferences, written releases, personal interviews, prepared fact sheets, press tours, or public meetings. Advance planning of procedures and assignments can greatly facilitate effective communication in the event of a crisis. The media play a special role in the public communication process, and the author provides several practical guidelines for optimal utilization of the media. Once the crisis is resolved, it is important to consider a forceful public relations program to retain public support and highlight the utility's strengths in coping with the recent crisis.

The article is informative and effectively illustrates the importance of a candid, accurate, consistent utility response in the event of a crisis situation.

91

Norseth, Palmer. 1980. Emergency Planning for Water Supply Protection. Opflow 6(7):1,7.

The author discusses the efforts of the Portland, Oregon, Bureau of Water Works to prepare for the threat of volcanic eruption and delineates lessons learned following the May, 1980, eruption of Mt. St. Helens.

The city of Portland is located approximately 50 miles south of Mt. St. Helens. At the time of the eruption, the city's water supply source was a 102-sq mi forested watershed located 25 miles east of the city. The watershed contained three impoundments which provided 21 bil gal for a service area population of 650,000. The water supply was unfiltered and treated solely by disinfection with chlorine and ammonia.

In March, 1980, the Bureau of Water Works was alerted by the U.S. Forest Service and the U.S. Geological Survey to the possibility of volcanic activity. The Oregon state geologist provided information on the potential impacts of an eruption and the bureau began to develop a contingency plan for contamination by volcanic debris. The plan measures included (1) provision for the addition of caustic soda at the headworks to adjust the pH of the water if acid rain or ash should fall in sufficient quantity to warrant treatment; (2) increased chlorination to accommodate an increase in turbidity; (3) development of an operational plan to bypass the five open distribution reservoirs in Portland if those storages were contaminated; and (4) provision of ash collection and rain sampling stations to determine the composition and quantity of ash fallout in the watershed.

The first ash fell within the watershed on March 30. The fallout was light but provided the opportunity to analyze its physical and chemical properties. The bureau initiated weekend patrols of the watershed and laboratory staffing and was placed on the "hotline" from the U.S. Forest Service Command Post in Vancouver, Washington. On May

18, Mt. St. Helens erupted, sending a cloud of ash 63,000 ft into the air. Prevailing winds carried the ash easterly across the cities of Yakima and Spokane, sparing the Portland area. Portland public works and waterworks personnel assisted Yakima in the response effort, gaining valuable experience in volcano emergency response planning. Lessons learned from the Yakima experience indicate that utilities should (1) provide approved dust respirators for all persons working outdoors; (2) restrict outdoor activity to essential functions for both citizenry and workmen; (3) establish good communications through the media; (4) protect equipment--automotive, electrical, pumps, and motors--from the ash fall; and (5) prepare for such contingencies by stockpiling essential items, such as respirators, air filters, and oil filters, and by developing an interagency support plan. As part of its volcano emergency preparedness program, the Bureau of Water Works initiated the construction of a 100-mgd well field and a 50-mil gal covered storage reservoir as emergency supplies to further reduce the risk of an interruption in supply.

The article provides a useful introduction to contingency planning for volcanic events and offers concrete examples of both preparedness and response activities.

92

Novak, John T. 1975. Planning for Emergencies at Water Utilities. Journal of the American Water Works Association 67:164-166.

The article examines the process of preparing for potentially extreme water emergencies. The author reviews the basic steps of emergency plan development.

There is frequently a disparity between utility preparation for routine emergencies and utility preparation for disaster situations. While most utilities acknowledge the necessity of planning for pump failures, line breakage, and other common water emergencies, few are willing to direct financial resources toward low-frequency, high-intensity disaster preparation. It is during such disasters that water supply may be of critical importance for fire fighting or medical requirements, yet the provision of water may be difficult or impossible due to contamination, power outages, and disruptions in communication and transportation. Normal responses may become infeasible in the postdisaster period, e.g., the inability to boil contaminated water due to power losses or broken gas lines.

The range of possible disasters is so great that it is neither practical nor desirable to attempt to plan for all possible occurrences. Most disasters produce common effects, so that provision for a variety of possibilities can be achieved for low incremental costs over those of preparing for the most likely or most severe event. There are, however, certain protective measures that are disaster-specific and that should be considered in terms of the probability of a specific event. For this reason, it is recommended that several potential disasters be considered so that training and expenditures can be applied to a variety of emergencies in order to maximize results.

The author describes vulnerability analysis as an iterative process in which each element of a system is assumed to be subjected to a series of disasters and the possible effects estimated. The two elements that appear to be most vulnerable to disruption are the availability of trained personnel and the availability of power to operate treatment, pumping, and distribution facilities. Specific steps for the vulnerability analysis procedure are given, which will illustrate system weaknesses if applied to a variety of probable events. Upon completion of a vulnerability analysis, a utility may choose absolute protection, which attempts to limit the direct effects of a disaster, or protective measures to facilitate rapid postdisaster recovery. Protective measures may be "hard" or "soft." Hard measures involve expenditures for equipment or structures, while soft measures involve time and planning but require minimal equipment or construction costs. The author lists general protective measures that are applicable to any utility or emergency situation.

Guidelines for the development of an emergency operations plan are given, with an emphasis on employee preparation. Employees should be responsible for reporting to supervisors without notification, each employee should know his/her appropriate duties and supervisor, since instructions may not be immediately available; and supervisory personnel should have detailed descriptions of their responsibilities. The use of training sessions or drills is advocated to ensure that employees are prepared and that equipment is functional. The author notes that while damage from disasters cannot be totally eliminated, emergency planning can minimize effects and limit disruption for water utilities.

The article is concise and informative, with clear guidelines to the emergency operations planning process.

93
Office of Civil and Defense Mobilization. 1958. Minimum Potable Water Supply Requirements in Civil Defense Emergencies. Washington, D.C.: Office of Civil and Defense Mobilization.

This article suggests minimum requirements for the quantity and quality of potable water to be provided during a national emergency.

Hospitals and other medical care facilities must be given the highest priority for available potable water supplies, followed by disaster workers and persons being cared for at mass care centers or other welfare installations. Persons occupying homes and apartments after an enemy attack should be able to survive for the first 14 days on stored supplies of potable water and other fluids, provided that they have been suitably educated and are prepared for emergency self-protection.

Water requirements for hospitals and other medical care facilities will be at least 5 gal per casualty treated during the first 12 hours and will increase to 15 gal per 24 hours as medical care facilities fill with casualties. When full medical services are extended, at least 25 gal per patient per 24 hours will be required for cleaning, essential laundry, and use at sanitary facilities. For mass care centers and other welfare installations that provided both lodging and emergency feeding, at least 5 gal per person should be available for the first 12 hours, increasing to 10-15 gal per person per 24 hours if fallout conditions permit. Where lodging only is provided, 2 gal per person per 24 hours will suffice for drinking and hand and face washing. At mass feeding stations, requirements will be at least 3 gal per person during postattack hours and at least 10 gal per person per 24 hours thereafter. Where sewer facilities are available and toilet flushing is permitted, total water requirements will be at least 25 gal per person per 24 hours. Supplies for residential use should allow 5-15 gal per person per 24 hours for drinking, cooking, and cleansing and 25 gal per person when toilet flushing is permitted.

Biological and chemical warfare present extreme hazards to water supplies. Chemical agents may be readily identified through detector kits available to utilities. Where biological warfare is suspected, supplies should be heavily chlorinated (having a free chlorine residual of at least 5 ppm, 30 minutes after dosing). In disaster situations, all untreated water should be considered contaminated until treatment and testing prove otherwise. Where appropriate, supplies should be monitored for radioactive contamination. Bacteriological safety is the primary consideration in the quality of potable emergency supplies, although attention must be given to taste and odor so that the public does not seek a better-tasting but unsafe supply. Where biological warfare can be discounted, or where flocculation, sedimentation, and filtration treatments may be provided, chlorine doses may be reduced so that residuals after 30 minutes are at least 2 ppm.

The article offers useful emergency water use estimations.

94

Omohundro, John T. 1980. Oil Spills: A Public Official's Handbook. National Oceanic and Atmospheric Administration, Rockville, Maryland.

This handbook is designed to assist public officials in addressing the social problems following an oil or hazardous substance spill, particularly in water. The major source of information for the handbook is a social study of a major oil spill on the St. Lawrence River in 1976.

The author identifies the reactions of the victims and coastal residents of the impacted area and suggests several actions that may reduce social problems. The specific suggestions for planning and response include:

(1) Integration of the impacted region with the official spill team's activities should be pursued in order to provide the liaison to the impacted community.
(2) Prompt, accurate, and continuing information programs after spills are imperative to provide residents of the impacted area with both background and emergency information that cannot be provided by the news media.
(3) The disaster culture of the region can be improved by informing the key individuals in the area who become active after a spill.
(4) "Red Cross syndrome" difficulties in relations between victims and helpers can be overcome by ensuring that public agencies are more straightforward and assume a higher intelligence of the public at large.

The author recommends this handbook to public officials for preparing for public meetings and news conferences, for conducting personal interviews, and handling telephone and written requests for information or help during emergency.

95
Ottman, E., and H. Leeb. 1977. The Automated and Computer-Controlled System for Water Monitoring in Bavaria. Progressive Water Technology 9(5,6):161-165.

This short paper describes a system of integrated measurement network in Bavaria which is comprised of 35 automatic measurement and computer-controlled stations and two central stations located in Munich. The network monitors water level, precipitation, and several water quality parameters and teletransmits the measurements to Munich by telephone lines.

The central stations in Munich are equipped with WANG computers, peripherals, and interfaces for teletransmission of data through a D2OP modem and a connection to an IBM computer.

96
Peisch, William Kent. 1977. Water-Quality Problems from Vandalism at Storage Reservoirs. Journal of the American Water Works Association 69:309-311.

The article examines the importance of potential security breaches in water utility contingency planning. The author reviews appropriate response procedures.

The first step in security-breach contingency planning is a field inspection of the perimeter fence at each storage facility. The fence should be carefully evaluated for possible points of entry. Facilities inside the fence should be checked for strength and tamper-resistance, e.g., checking the strength of screen vents or hasp-and-padlock closures. Shrubbery and trees used in landscaping should not conceal entrance gates and access ways. Valves may be particularly vulnerable to intruders.

Once security weaknesses have been identified, steps should be taken to fortify vulnerable areas. Damaged fences and broken locks should be repaired, with protective covering added where possible. Through bolts, rather than wood screws, should be used to fasten hasps on wooden frames. On steel hatches, hasps should be welded rather than bolted. The screening on vents should be of heavy material, and if possible, a solid plate baffle should be installed behind the screen to catch material before it reaches the water. Locks are needed on access ladders and stairways of above ground tanks, and it is best if conduits, pipes, and other external equipment do not provide a means for scaling the walls of the tank. Uncovered reservoirs present special problems. Perimeter protection is very important to increase water safety and to reduce the risk of legal liability for unauthorized access. Uncovered reservoirs located next to a public street may be vulnerable to materials thrown from the street. Security guards are usually not cost-effective unless used for other purposes in addition to patrol. Alarm systems can offer varying degrees of protection, but instances of failure and false alarms are not uncommon. At one California utility, intruders actually stole the alarm system.

Safety features can be included in new construction at costs much lower than those required for retrofitting existing structures. The design of all external features should be considered from the standpoint of their effect on security. Other design features may provide additional protection to a water supply system, such as the development of a storage tank that can be drained without involving the distribution system if contamination should occur.

Vandalism can consist of physical damage to structures, to inlet and outlet lines, or to attendant control facilities. This type of damage may affect an entire service area. Vandalism of stored supplies, however, may have more serious consequences for the utility and result in the total loss of water supply. If evidence of contamination is strong, the utility can take steps to treat or discharge the contaminated supply. If vandalism is suspected, but there is no information on the type or degree of contamination, the utility is faced with a very difficult problem. Advance planning for such a contingency consists of three procedures: (1) field personnel should be trained to recognize signs of tampering and to check for evidence to aid in the identification of possible contaminants; (2) the facility should be taken out of service immediately if evidence, actual or circumstantial, indicates that supplies may have been tampered with;

and (3) samples should be obtained from the water supply to the tank, from the stored water, and from the immediate service area of the facility.

Time constraints should be considered when selecting tests for water samples. The necessity of rapid restoration of service may preclude certain lengthy testing procedures. Several tests are available to rapidly compare samples from the stored water to those from the system or supply source. Unless an initial investigation reveals an unsalvageable supply, the stored water should be chlorinated after the samples have been drawn and before any tests are run. Chlorine is a useful tool for treating several different types of contamination, including virus, bacteria, organic pesticides and herbicides, and LSD or other organic drugs. Additionally, chlorine can convert toxic forms of cyanide and mercury into nontoxic forms. After 24 hours, tests should be repeated and a final decision made regarding the return to service.

The article is concise and informative. The author provides a wealth of practical information to assist water utilities in evaluating their security needs.

97

Phillips, Robert V. 1973. Joint Discussion--Utility Emergency Planning Pays Off: Los Angeles Earthquake of Feb. 9, 1971. Journal of the American Water Works Association 65:477-479.

The author briefly describes water system damages resulting from the 1971 Los Angeles-San Fernando earthquake, recounts utility disaster response efforts, and offers recommendations to facilitate a water system's utilization of outside aid in emergency situations.

On February 9, 1971, an earthquake of Richter magnitude 6.4 struck the Los Angeles area. Damages were concentrated within a 28-sq mi area in the San Fernando Valley. Virtually all water systems within the area sustained damages, and the loss of water services was extensive. The Los Angeles Department of Water and Power had traditionally avoided the use of outside contractors in distribution system constructions. As a result, the department had its own trained construction force available for immediate disaster response. Operating and construction personnel knew the system well and were able to respond rapidly, with minimal guidance from utility management. Personnel had standing orders to report to their normal working locations as soon as their families were secured. For smaller utilities, such as the San Fernando Water System, the maintenance of a large work force is often financially infeasible; these utilities depended on outside aid to restore their water systems. Although the state of California has a mutual aid law and a state disaster organization, the assistance rendered by several neighboring communities was extended outside the formal provisions of the mutual aid act. Most of the repair and restoration work for the city of San Fernando was accomplished by the Army Corps of Engineers under the authorization of the Disaster Relief Act of 1970. However, for reasons not given here, the Corps was not authorized to act until five days after the earthquake. The Corps was handicapped in its efforts to construct a temporary above-ground water system and repair existing components by its unfamiliarity with the San Fernando system and by the lack of adequate maps and records.

A utility with its own work force, well equipped with the appropriate tools and stocks of materials, is very flexible in responding to any emergency. The author states that an adequate in-house work force eliminates the need for an extensive written emergency plan, with the exception of emergency communication procedures and facilities. When outside assistance is required, it may take time to obtain the necessary responses from state and federal agencies. Six recommendations to help utilities use outside aid effectively are given: (1) train and maintain a core of employees familiar with the organization and with the arrangement and construction of its facilities; (2) maintain or develop good maps, records,and schematics of facilities; (3) construct interconnections with contiguous water systems and establish a liaison with their organizations; (4) study state and federal disaster-relief procedures and establish a liaison with the appropriate governmental offices; (5) prepare and distribute to key personnel a simple outline of initial emergency procedures; (6) plan for communication requirements during emergencies.

The article illustrates the potential advantages to emergency preparedness of maintaining an in-house work force and provides useful guidelines to facilitate the use of outside assistance when required.

98

Public Works. 1969. The California Water Project and Earthquake Engineering. Public Works 99:65-67.

This short article summarizes information contained in a progress report entitled "Earthquake Engineering Programs," issued as Bulletin No. 116-4 of the California Department of Water Resources prepared under the direction of Renner B. Hofmann. The article describes an attempt of the department to develop earthquake hazard and engineering criteria which would apply to the California State Water Project.

The project is likely to be subject to earthquakes of varying intensities as well as other ground movement phenomena. Aqueduct facilities cross known active faults at the surface rather than in tunnels to facilitate repairs after the earthquake. The data collected by the department were used to test conventional design procedures that were the basis for most project construction. The results have allowed the department to develop failure criteria for saturated sand based on the number of earthquake pulsations, overburden and pore pressures, and degrees of saturation, compaction, and composition. Also, a computer model was developed calculating the distribution of internal stresses in earthfill structures. One of the major findings of the research project was that, in general, structures not designed for earthquake loadings suffer more damage on soft saturated alluviums than on hard rock due to more violent vibrations of the former.

99
Richards, W. Thomas. 1984. Do You Plan for a Disaster? In Proceedings, American Water Works Association Annual Conference, pp. 937-940. Denver: American Water Works Association.

The author briefly describes three case histories of emergencies experienced by the Denver Water Department and offers basic guidelines for the development of emergency operations plans.

The first case history involves the threat of flooding caused by the overtopping of a dam. Due to unusually heavy rainfall, an already full reservoir was receiving 1050 c.f.s. from a source canal and creek. Local agencies were asked to evacuate the community downstream of the dam, but efforts were hindered by the absence of an emergency plan or listing of local agencies. Crews stumbled upon maps illustrating five canals or ditches with diversion structures located upstream of the threatened community and, working through the night, were able to divert the overflow and avoid a flood disaster. In a second case of reservoir overflow, the facility caretakers were stranded when dam overflow flooded a large portion of the sole access road and remained flooded for nine months. Again, the lack of an emergency plan hindered prompt response. Fortunately, the caretakers had sufficient food supplies on hand, even though no specific emergency preparations had been made. A third emergency involved a construction accident during the building of Gross Dam that killed nine workers and permanently disabled three others. During construction of the keyway, blasted out of rock, the contractor had drilled holes and was packing them with explosives when a sudden electrical storm produced enough static electricity to prematurely detonate the explosives.

When the Denver Water Department decided to institute emergency planning, an earlier plan developed in 1958 was unearthed but found to be overly complex and difficult to use. The utility determined that emergency preparedness plans exist primarily to assist the personnel responsible for responding to a given situation and decided on the formulation of a plan that would (1) be brief and easily referenced, (2) assign responsibilities to persons familiar with the operation, (3) have people and agencies listed in order of priority with updated telephone numbers for each, and (4) contain all the maps and drawings necessary to respond to a given contingency. A distinct plan was developed for each facility, and two different emergency centers were established. One emergency center, which is activated by the mayor's office, is located in the city of Denver and is coordinated with all agencies within the city. The second emergency center is activated by the manager of the Water Department for emergencies occurring at outlying facilities and involves agencies other than the city of Denver. The staff at each facility are responsible for updating the emergency plan every six months so that the plan remains current and the personnel remain familiar with the plan.

The article illustrates the importance of contingency planning for water utilities and provides instructive guidelines for plan development.

100
Ring, Chester A., III. Joint Discussion--Utility Emergency Planning Pays Off: Flooding in New Jersey. Journal of the American Water Works Association 65:479-480.

The author provides a brief case history of the August, 1971, flooding of the Elizabeth, New Jersey, water system.

Eleven inches of rainfall within a 29-hour period resulted in the inundation of the Elizabethtown Water Company's 150-mgd capacity filter plant, which remained inoperable for over 36 hours. On the afternoon of the flood, all neighboring water suppliers were contacted to arrange for emergency supplies. The principal water suppliers dependent on the Elizabeth Water Company for all or part of their water supply were asked to switch to other supply sources. The company's wells were not seriously affected by the flooding and service from them was increased as much and as quickly as possible. Initially, service was maintained by utilizing system storage. The operating and planning departments worked throughout the night to arrange for repair and restoration assistance. In addition to alerting the company's crews and supervisory personnel, arrangements were made for electrical technicians from neighboring states; for equipment and personnel from contractors; for stone from a local quarry for repairing washed-out roads; for diesel fuel supplies to replace fuel affected by the flood; and for miscellaneous parts and supplies. All personnel, equipment, and supplies were to be collected by dawn. Upon conferring with state Environmental Protection personnel, company managers issued a boil order for all customers as a precautionary health measure. Boil orders were removed three days after the flood; full production was restored on the fourth day. Throughout the emergency, the company switchboard and executive offices were manned continuously.

The author provides an informative account of a water emergency that could be useful to utility managers in planning their own emergency responses.

101

Rosenthal, Meyer. 1983. Surviving the Johnstown, PA., Flood. Journal of the American Water Works Association 75:390-393.

The author describes the damages to a community water system following a major flood and offers recommendations for water utility emergency planning. A case history of the 1977 Johnstown, Pennsylvania, flood is given.

On July 19, 1977, the city of Johnstown and adjacent municipalities were hit by a reverse flood following torrential rains that dumped 12 inches of rainfall within a period of seven to eight hours. Reverse flooding entails flooding of high elevations as well as low-lying areas due to particularly intense rainfall and runoff. Weather experts estimate that the rainfall experienced in the Johnstown area occurs only once in 5,000 years. The Army Corps of Engineers had declared Johnstown a flood-free city as a result of structural improvements following the flood of 1936, and the city was completely unprepared for such a disaster. The flood virtually demolished the Greater Johnstown Water Authority's system. Of the 22,500 households served by the system, over 50 percent are supplied by a gravity system fed by five impounding reservoirs; the rest are supplied through six separate and totally independent pumping stations. The Benscreek operating station, which served as the control center for the entire system, was severely flooded and lost all telemetering and electronic control systems, all communication, electrical power, and all means of transportation. More than half of the population served was without service. The provision of temporary service to some areas required more than four weeks. Two of the five sources of supply were lost, representing 40 percent of normally available supply. Two of the six pump stations were destroyed, and electrical power losses hampered production at the surviving facilities. The utility obtained water from three adjoining water utilities by running fire hose from the other utilities' hydrants to surviving hydrants within the Johnstown system. Chlorinators were destroyed at two of Johnstown's sources of supply, and nearly all of the utility's remote control equipment was destroyed or badly damaged. Supply lines were washed out throughout the service area.

At the time of the flood, the water utility had no specific disaster plan. Based on their experiences, several recommendations are made concerning water utility preparedness. An emergency plan should automatically organize personnel into operating teams with specific functions to perform that are within the scope of each person's expertise and capability. The community health organization should be involved in the emergency planning, and plans should include coordination of various community utilities such as water, electric, gas, and transportation. Food and beverages should be stored for employee use in preparation for long hours, isolation, and loss of area food establishments. All employees physically involved in recovery operations should have tetanus shots, although routine disaster preparation should include tetanus shots for all labor personnel. An inventory of all water sources available to a community should be maintained, with information on the quantity, quality, and location of each. Alternative sources of supply for industrial and fire-fighting purposes should be identified. Each component of a water system should be able to operate at maximum capacity for a sustained period. Provisions should be made for monitoring water supplies, treatment supplies, and equipment against chemical and biological contamination, and a testing laboratory with qualified chemists should be available. Portable water testing kits should be available in case the central lab is damaged or affected by gas or electric losses. Portable chlorinators should be maintained as well.

A dependable communication system that can function independently of local radio and telephone systems is extremely important to the recovery effort. A list detailing emergency priority allocation should be formulated so that critical water needs may be met. The distribution system should be zoned by key engineering personnel to isolate potential problem areas by operating valves. Detailed drawings of the entire transmission and distribution system should be developed, and records kept of all valve activities. Plans should be developed to assign major repairs, rebuilding, or new construction to particular firms or individuals, and managers should be familiar with the labor and equipment rates allowed by the Federal Disaster Assistance Administration. All reservoirs, intakes, and supply lines should be checked immediately after a disaster occurs, followed by an inspection of mains and large service lines. If remote control or monitoring equiment is used, provisions should be made for manual operation. An alternative power source is essential, and standby generators should be compatible throughout the system to allow use at more than one location. Prearrangements should be made for the rental or purchase of replacement vehicles, supplies, and equipment. All meters within the affected area should be tested. Sources contributing to major supplies should be checked for disruption. The public must be kept informed of problems and progress in recovery, and all restoration work should be documented in writing and through photographs.

The article is concise and informative. The author provides clear, specific emergency operations planning guidelines that are well illustrated by the experiences of the Johnstown utility.

102

Russell, Hugh. 1978. The Roles of Public Policy and Public Information in Mitigating Disasters. For the Emergency Preparedness Project, National Governors Association. Washington, D.C.: Defense Civil Preparedness Agency.

This document examines the role of state governments in mitigating and preventing natural and man-made disasters through public policy and public information programs. It provides definition of emergency planning concepts and nonstructural measures tied to proposed planning and coordination actions among private interests and various levels of government. A bibliography is included with frequent citations and examples of case situations where emergency management measures have been implemented.

Seven disaster trends are cited to support the growing interest in mitigation and prevention measures, such as increased incidence in man-made disasters, increase in property losses while loss of life remains generally stable, and continued building in hazard-prone areas coupled with an apparent indifference of the potential catastrophic consequences reflected in public policy.

Following a clear presentation of definitions of hazards, disasters, potential planning methods, and selected planning actions, the author reviews the four phases of management activity (mitigation, preparedness, response, and recovery) conducted by four levels of managers (private sector; local, state, and federal governments) on behalf of all natural and man-made hazards. These components and their integrated relationships in a thorough planning process were introduced in the Comprehensive Emergency Management (CEM) program originating in the 1978 National Governors Association study of state government emergency preparedness. That report observed that although states reflect well-prepared plans and response mechanisms, recovery efforts remain unintegrated with either of these two phases and divorced from mitigation or prevention measures.

The author provides a supporting discussion of why this integration between prevention and mitigation on one hand and disaster preparedness and recovery on the other is required for emergency management. He proposes research to explore useful means for evaluating mitigation effectiveness for both natural and man-made disasters which may include resulting changes in the probability of hazard occurrence, in risk, in public awareness and involvement in mitigation and prevention measures, and, for the same hazard, a comparison between costs of mitigation and prevention with response and recovery and the term for recovery with and without mitigation and prevention measures.

Although this report encompasses general emergency management for all types of potential hazards, it represents an excellent perspective readily adaptable to emergency water planning.

103

Rutgers University Department of Environmental Resources. 1977. Water Supply Emergency Response Plan. Prepared for the Division of Water Resources, New Jersey Department of Environmental Protection.

This report presents a New Jersey state plan for the provision of safe drinking water under emergency conditions.

An emergency is defined as an event, whether natural or man-made, which causes a water supply system to encounter a major disruption of its function not resulting from normally occurring operational disorders. The state's response to water supply emergencies is directed toward large scale or major emergency situations in which the effects would be felt by water purveyors on a regional or statewide basis, or large numbers of people on a local basis. Local emergency response plans are the responsibility of individual water purveyors; the state's plan will provide a basis for coordinating local plans. The events considered in the state response plan are hurricane, flood, civil disorder, hazardous spills, tornado, earthquake, and nuclear contamination. The potential effects on water supply systems include structural damage causing disruption of service (plant operating equipment), watershed damage, reservoir damage, storage tank or distribution reservoir damage, broken transmission mains, contamination, prolonged power outages, and employee shortage.

A State Water Supply Emergency Group, consisting of the deputy director of the Division of Water Resources, the assistant director of Water Supply and Flood Plain Management, and the chief of the Bureau of Potable Water, will evaluate the emergency situation in terms of the extent of the emergency and the quality and quantity of water available in both existing and alternate sources. If the State Water Supply Emergency Group determines that state involvement is necessary, possible actions would include gathering tank trucks and other transportable water sources, providing technical assistance, providing assistance in locating alternate sources of supply, determining the quality and safety of alternate sources of supply, evaluating the quality of existing sources, locating available repair equipment, locating civil defense materials, notifying the public via communication media, soliciting assistance from other water purveyors, coordinating activities, and broadcasting water conservation measures. The State Water Supply Emergency Group is responsible for determining when the emergency is over and for declaring an end to the emergency by notifying the media and issuing appropriate public service messages.

The state plan details emergency responsibilities of agencies on the federal, state, and local levels; inventories of emergency equipment available from federal facilities in EPA Regions II and III; and a discussion of the statutory authority for implementing emergency actions. Comprehensive water utility guidelines for emergency planning are provided to guide local water purveyors in their development of local emergency response plans. The guidelines are based on those of the American Water Works Association Manual No. M19, Emergency Planning for Water Utility Management. An Interagency Emergency Communications flowchart is provided, as is an emergency event and effects matrix.

The New Jersey State Emergency Response Plan provides a valuable example of emergency water operations planning at the state level.

104

Rutledge, Everard O. 1984. Managing a Flooded Community. Journal of Environmental Health 46:261-262.

The author describes the efforts of environmental health personnel to respond to a major flood and offers recommendations for future emergencies. A case history is given of the December, 1982, flood in St. Louis County, Missouri.

During the first week in December, 1982, the lower Meramec River in St. Louis County, Missouri, exceeded the 500-year flood level and rose to a height of 23.5 feet above flood stage, setting a new record for this century. The St. Louis County Department of Community Health and Medical Care (DOCHMC) played a major role in the cleanup activities. Public and private water supplies had to be purged and replenished. The Health Department issued boil orders to remain in effect until samples could establish that systems were free of contamination. Bars, restaurants, and food stores were inspected and denied authorization to reopen until their water supply had been approved. Sanitary standards were strictly enforced. Air pollution personnel patrolled the area to locate and identify hazardous materials; collections points for disposal were established with the cooperation of EPA officials, Coast Guard crews, and local businesses. The flood provided the first test of the new Emergency Operations Plan for St. Louis County. Top officials from key county departments staffed a command post around the clock, and five shelters were established in the flooded area. The Health Department distributed leaflets detailing procedures for the disposal of trash, ruined household items, and damaged food. Dead animals were quickly removed and a rabies alert was issued due to the increased risk from wild animals dislocated by the flood. Public Health staff provided tetanus shots and other medical assistance at the shelter areas, and Health Education personnel prepared periodic news releases to disseminate information to flood victims. DOCHMC managers held daily meetings to coordinate activities and facilitate the exchange of information between all units of the Health Department.

Problems encountered included conflicting advice issued by different "experts," poor communication systems, and the failure to include Public Health nurses, who had special knowledge of the people, flooded area, and Department resources, in the command post staffing.

Many recommendations were made concerning flood response activities. The development of an internal communication system to handle numerous sites, apart from the regular telephone system, was seen as a high priority. The Health Department sought more control in condemning food products at food-related businesses and recommended an arrangement with the nearest sanitary landfill for direct disposal of flood-damaged goods. Other needs included the maintenance of a single telephone number regardless of changes in command post location, the establishment of a special environmental/health command post with at least one medical attendant and one environmental health expert available each shift, the development of an identification system to simplify access of authorized individuals to the disaster area, and the stockpiling of emergency supplies and equipment to reduce response time. In the future, DOCHMC will maintain an official daily journal of activities to record the sequence of events, changes in direction, response to change orders, and other relevant data.

The article is informative and provides useful insights to potential strengths and weaknesses of a coordinated disaster response effort.

105
Ryckman, D. W., and Mark D. Ryckman. 1980. Organizing to Cope with Hazardous Material Spills. Journal of the American Water Works Association 72:196-200.

The article describes a private systems approach to coping with hazardous material spills that threaten drinking water supplies. The authors utilize system assessment and illustrative case studies.

Two systems must be considered when formulating a hazardous material response effort. The first system describes the specific interactions of the material with the environment,and the second system deals with the management system employed to respond to the problem. The REACT (Ryckman's Emergency Action & Consulting Team) system is a management system for responding effectively to hazardous material spills.

The authors list twelve essential system components of an emergency action response: (1) Fast response is the most important component. The emergency response center must be prepared to act on the first call. It is in this early stage that the local water utility should be notified of the imminent threat to the water supply. (2) An experienced staff should include on-call experts and multidisciplinary in-house personnel. (3) Leadership is crucial--it is important to have one person in charge during an emergency, such as an on-scene coordinator (OSC). (4) Rapid, reliable communication systems are vital to an effective emergency action response. (5) Availability of information, equipment, and personnel must be maintained 24 hours a day, seven days a week. (6) All efforts must be coordinated among several agencies. Coordination of all agencies and operations is often more difficult than the response effort itself. (7) The manpower involved generally includes three types of personnel: leaders, operators, and researchers. (8) Equipment and supplies availability must be maintained through a system of warehouses and suppliers. (9) Data resources must be readily available. A computer assist program (CAP) developed by REACT provides immediate information on physical, chemical, and toxicological properties of some 250,000 materials; appropriate containment, removal, recovery, treatment, and disposal practices; hazardous material experts classified by discipline and location; location of equipment and material suppliers, including mobilization equipment; location of staging, disposal, recovery, and waste exchange facilities; medical clinics specializing in fields of industrial medicine; EPA- and FDA-certified analytical testing laboratories; a complete system of maps of the U.S.; government agency contacts; listings of water utility companies; and emergency telephone numbers. (10) Two types of laboratory facilities are required during an environmental crisis--mobile facilities to obtain rapid field information and mainframe labs to conduct sophisticated analytical evaluations. (11) Transportation must be available to mobilize personnel and equipment to and from emergency scenes. (12) Medical clinics provide specialist referrals or treatment of individuals exposed to toxic substances.

Management is divided among response centers. The corporate response center (CRC) coordinates all response activities. Satellite response centers (SRC) provide support services to the CRC and to the field response center (FRC), which is established at the accident scene.

Brief case histories are offered of the REACT system's application to a gasoline spill, an oil spill, and a phenol, alcohol, and solvents spill.

The article is informative. The emergency response system is thoroughly described and could serve as a valuable guideline to the establishment of other hazardous material spill response plans.

106

Sav, G. Thomas. 1974. Natural Disasters: Some Empirical and Economic Considerations. Report prepared for the Office of Federal Building Technology, National Bureau of Standards.

This study examines absolute and relative losses resulting from hurricanes, floods, earthquakes, and tornadoes and discusses the potential benefits that might be realized from mitigating the negative economic impacts of natural disasters. The application of benefit-cost analysis for choosing the optimal level of protection against disasters is discussed, two empirical studies of the economic benefits of disaster mitigation are reviewed, and recommendations are made for further research.

The economic impacts of natural disasters are usually described in terms of dollar losses resulting from damage to property, which do not reflect the full economic impact of disasters. Such measures frequently fail to include the losses in human lives, losses due to human suffering, losses in productivity, losses in the tax base and tax revenues, and social disruptions resulting from disasters. One interpretation of the social cost of a human life is the net loss in the productive value which that individual would provide to society over his expected remaining life span, which does not reflect the pain and suffering or psychological impact on relatives and friends or the loss in a community's tax base. The destruction or damage to a dwelling involves many cost categories. In addition to the replacement costs of the home and belongings, there are costs in inconvenience and discomfort that fámilities experience in relocation and temporary housing. Unemployed resources that result from natural disasters are also economic losses. Decreases in tax revenues for the community occur at a time when increased tax revenues are needed to meet the increased demand for public revenues stemming from postdisaster restoration activities. Communities surrounding a disaster area are afffected in several ways, as in cases where tourism and tax revenues are sharply reduced in communities that remained untouched by the actual disaster. Real property losses due to natural disasters display an increasing trend over time. Loss of life from natural disasters is generally decreasing over time.

Society can purchase protection from disasters through various techniques that are effective in reducing losses but must decide how much disaster protection is economical to purchase. Alternative levels of protection provide certain benefits and incur certain costs. Social benefits are the reduction of future potential losses, and costs (opportunity costs) are the benefits foregone by taking resources out of their alternative uses and applying them to disaster protection. The optimal level of protection maximizes the difference between the present value of total benefits and total costs. A second method of determining the optimal level of protection involves total cost minimization, where total costs are defined to include more than just the costs of protection (costs of protection plus total losses). The optimal level of protection is achieved when total costs are minimized. Both methods yield the same result.

The 1933 California Field Act revised building codes to improve seismic resistance of California schools. A U.S. Department of Commerce study comparing earthquake damages among schools revealed that schools constructed after the building code revision sustained less damage, as a percent of building value, than schools constructed prior to the code revision. The newer schools sustained an average damage-to-value percentage of 0.4 at an intensity of Modified Mercalli VIII, compared to an average damage-to-value percentage of 67.2 at the same intensity. However, the costs of code revision are not examined, so that there is no indication of the relationship of benefits to costs. A study examining the economic analysis of hurricane warning systems develops a game theory approach in which, given the probability (p) of a hurricane passing over a given area at a given time, the hurricane forecast should be given only if

$$p(aL + C) + (1-p)C < pL,$$

where C = cost of protection,
L = dollar losses resulting from a hurricane, and
a = the proportion of L which cannot be reduced through protective action.

If the primary concern in disaster protection is the reduction of dollar property damages, then initial efforts might be directed toward mitigating the effects of hurricanes and floods, which result in relatively higher property damage than do earthquakes and tornadoes. If the concern is the reduction of the loss of life, then the concern might be the mitigation of losses due to tornadoes, which have caused the greatest loss of lives. The costs of protection and the various techniques of protection must be considered in any analysis of disaster protection. Additional research is needed to determine the real losses (i.e., in real dollar terms) that individuals and society experience from natural disasters. Research is also necessary to determine the future potential losses which natural disasters pose to various areas of the country and the costs of alternative techniques for protecting against these losses. This additional knowledge would permit more comprehensive benefit-cost studies of alternative techniques of hazard mitigation.

This report provides a useful overview of issues pertaining to the full assessment of the economic impacts of natural hazards, which would facilitate knowledgeable decisions in emergency response planning.

107
Schinzinger, Roland, and Henry Fagin. 1977. An Outline for the Study of Emergency Water Allocation Procedures. Emergency Water Allocation Project, Working Paper No. 1. Irvine: University of California.

This document provides an outline for the study of contingency planning for potential water emergency for the San Diego County Water Authority. The outline details procedures and methodologies to be used in the accomplishment of the study.

The primary task of the study was to prepare technically feasible and socially acceptable policies for the management of a water system during emergency conditions. The 22 local water districts served by the San Diego County Water Authority were selected for the investigation because the region (1) is very vulnerable to disruption of supply due to its reliance on imported water and its lack of alternative surface and groundwater sources; (2) includes a full range of water users--domestic, municipal, agricultural, and industrial; and (3) has local authorities willing to cooperate with the investigation.

General procedures develop the creation of a data base, the evaluation of water needs and responsibilities, and the establishment of emergency policies. Intended methods of analysis include functional modeling of the water delivery system; stochastic dynamic programming of reserves and allocations; fault analysis to determine network reliability; and case studies of both past emergencies and simulations. The outline details categories of users, categories of supply, causes of water shortage, and categories of water shortage.

This report serves as a useful template for preparing a study directed at emergency water planning at the local or county level.

108
Schinzinger, Roland, and Henry Fagin. 1979. Emergencies in Water Delivery. Technical completion report No. 177. Davis: California Water Resources Center.

This publication presents a comprehensive overview of the etiology of water system emergencies, the basic steps in emergency preparedness, and a systematic response process. The San Diego County Water Authority and the Poway Municipal Water District in California are cited as illustrative examples throughout and relevant case histories are discussed.

Emergency is defined as an overlap of a potentially disruptive event with a state of vulnerability or unpreparedness which produces interruptions in water service of a magnitude judged to be injurious to the community's health and welfare. Two major conceptual models relevant to water system emergencies are presented. The first divides the general water supply system into three major parts: an operational system, an administrative system, and an external system. These three subsystems are linked by a communication system through messages, information, and controls. The second model considers the water supply emergency system. A focal system comprises all functions over which a given agency has complete control. The focal system operates within an environment composed of related support systems, user systems, and external control systems. Interaction between the focal system and related systems occurs through the exchange of resources, messages, and information.

Two major types of vulnerability analysis are discussed: scenario analysis and network analysis. Scenario analysis includes exploratory techniques, normative techniques, and human element analysis techniques. Network analysis includes evaluation of the reliability of networks with redundancy, graph-theoretic analysis of network connectivities and vulnerabilities, and solution of flow and pressures in water networks for comparison of alternative strategies. In addition, a review of residential, institutional, industrial, and agricultural water use and conservation is presented as the context within which emergency planning and response occur. The importance of understanding agency and public response to emergencies is emphasized and the authors examine common misconceptions of crisis behavior which may adversely influence emergency preparedness decisions.

Several emergency response operations are investigated. Initial response processes are (1) recognition of the onset of an emergency, (2) assessment of the nature of the emergency, (3) assessment of system capacity, (4) comparison of capacity with demand, (5) forecast of future water availability, (6) declaration of an emergency, and (7) determination of criticality if an emergency is not ultimately declared. Criticality involves a measurement of reserve capacity that provides an indication of how close to an actual emergency a system may have been. In analyzing the history of a system, a knowledge of narrow escapes can be as important as the knowledge of actual crises. Additionally, the authors discuss possible causes and remedies for interruptions of communication and failures of coordination in emergency response. The advantages and disadvantages of applying various water allocation strategies during crisis are described. Rate structure and water banking are explored as potential emergency preparedness measures. The advantages of planning the restoration process are given along with information on establishing restoration priorities and objectives, formulating alternative restoration strategies, and selecting alternative methods of sequencing restoration tasks. The section on emergency response operations concludes with an examination of emergency policies and mutual assistance.

This report provides a useful excercise in emergency water planning, although some sections are specifically directed to drought contingencies and not to acute water emergencies.

109

Schinzinger, R.; H. Fagin; T. Edwards; and G. Urbach. 1977. Emergency Water Allocation: Implementation of a Preparedness Program. Emergency Water Allocation Project, Working Paper No. 7. Irvine: University of California.

This is the first in a series of four papers describing a project that assisted water districts in San Diego County, California, in the formulation of water allocation and system restoration procedures to prepare for sudden emergencies. This paper states the emergency problems and describes the development of an emergency plan for a particular agency, the Poway Municipal Water District.

An emergency is defined as a situation in which a large service area can be expected to be without water for three days or more, or when fewer water users, but users with critical needs, lose service for a prolonged period. A major emergency is defined as a situation in which substantial outside assistance is required and/or where restoration of service to a majority of users cannot be expected for at least a week. A major disruption of a water system may impose serious reductions of service on adjacent systems which are committed to sharing their resources. The vulnerability to such disruption varies from one utility to another. Overall, the weakest link in the Poway system was discovered to be the treatment plant.

The events surrounding a water emergency can be grouped chronologically: (1) predisaster conditions--the state of the system before a potentially disruptive event occurs; (2) occurrence of a potential threat; (3) impact on the water system--onset of disaster; (4) assessment of damage; (5) emergency measures--makeshift water service and emergency repairs; and (6) repairs and restoration of full service. A standard ranking of water allocation priorities during an emergency is to satisfy: (1) fire protection needs, (2) domestic use, (3) hospitals, (4) other public institutions and industry, and (5) agriculture. However, complicating questions and constraints concerning allocation affect the determination of priorities. Priorities may be assigned by applying a point system, an example of which is provided. Following the determination of priorities, the restoration of service to affected areas in order of priority can be scheduled. In anticipating restoration activities, an index proportional to the priority points and inversely proportional to required completion time is advocated. Other considerations include implementing allocation and financial accounting for emergency-generated expenditures.

The emergency plan developed for the Poway district was structured around three emergency phases--initial measures upon the onset of an emergency, operations under continuing and major emergencies, and administrative decisions and implementation. Emergency response reference data for the district were collected and arranged in an extensive series of appendixes.

The article provides practical methods for assigning water allocation priorities and estimating postdisaster restoration activities.

110

Schinzinger, R.; H. Fagin; T. Edwards; and G. Urbach. 1977. Manual for Water Service Emergencies for the Poway Municipal Water District. Emergency Water Allocation Project, Working Paper No. 11. Irvine: University of California.

This manual provides guidelines to be used by municipal water district personnel during major water service emergencies. A detailed sequence of response procedures is developed, and appendixes compile practical information to provide references during emergency situations.

The manual organizes emergency response into three progressive phases: (1) initial measures upon onset of an emergency; (2) operations under continuing and major emergencies; and (3) administrative decisions and implementations. Activities during the first phase are the responsibility of the water superintendent and include (1) receive and forward first news of the emergency; (2) make an initial assessment of damages and needs; (3) take immediate emergency measures; and (4) prepare for operations under a continuing and major emergency. Activities during the second phase are conducted under the overall direction of the general manager and include (1) arrange a board of directors meeting and liaison with other agencies; (2) make continuing assessments of surviving water supplies and needed repairs; (7) propose suitable restoration measures; and (8) propose suitable water allocation measures. Third-phase activities must be approved by the board of directors and include (1) deciding on and implementing mutual aid; (2) setting restoration priorities and schedules; (3) setting emergency water allocations; (4) invoking appropriate ordinances; (5) announcing emergency measures to the public; and (6) monitoring compliance.

The appendixes contain worksheets and information with which water utilities may develop emergency response references. Guidance is provided for (1) listing contacts and addresses; (2) compiling a resources directory; (3) detailing alternative means of communications; (4) regulating message flows; (5) locating and equipping emergency operations centers; (6) calculating the status of water supplies and making forecasts; (7) undertaking damage assessment and restoration scheduling; (8) implementing water allocation measures; (9) compiling water authority bylaws relevant to emergency response; (10) listing mutual aid agreements; (11) compiling relevant ordinances; and (12) formulating and coordinating public announcements.

The manual offers a substantial collection of information and guidance and constitutes a valuable reference for water utility managers.

<u>111</u>
Schinzinger, Roland; Lemba Davy Nyirenda; Magdy Saeb; and Ali Peiravi. 1983. <u>Integrity of Interconnected Water Systems</u>. Technical Completion Report. Davis, California: California Water Resources Center.

This report examines various theoretical and applied network theory approaches for assessing the reliability of water distribution systems. Two categories of reliability models are presented: (1) flow reliability concerned with pressure and flow rate and (2) topological reliability, which is concerned with the existence of adequate connections within the system.

The results of the sensitivity analyses showed that the parameters that affect the flow reliability include the reliabilities and capacities of individual components of the system, the topology of the network, and the flow demand.

<u>112</u>
Sears, Larry M. 1977. Management Training. In <u>Proceedings, American Water Works Association Annual Conference</u>, Paper No. 30-3, pp. 1-11. Denver: American Water Works Association.

The author recounts the management cross-training experiences of a municipal utility and illustrates the usefulness of such a program to utility emergency preparedness.

In 1975, the Utilities Department of the city of Anaheim, California, found itself embroiled in prolonged contract negotiations with two major labor organizations. Although a strike was never called, the employees represented by the organizations became suddenly unavailable for duty outside of regular working hours, and remained unavailable for the entire six months of contract negotiations. With no employees responding to emergency call-outs, the utility was forced to implement a crash cross-training program to enable management personnel to respond to emergency calls. Much of the training was accomplished through on-the-job training sessions augmented by classroom sessions. Only the personnel not involved in current disputes and not likely to become involved were eligible for cross-training. Seven people from the Water Division and six from other divisions in the Utilities Department were assigned to the program.

A training site adjacent to the department's storage yard was developed to facilitate hands-on training. Although some training was done by various vendor representatives, the use of outside resources was minimized in both the training program and the actual emergency responses. Safety aspects were heavily emphasized due to the unfamiliarity of most management personnel with tools and heavy equipment. Personnel with past field experience were invaluable as instructors and as emergency call-out personnel. Skills of available personnel were inventoried and individual were assigned to existing field classifications (e.g., equipment operator, maintenance pipefitter, laborer), which allowed dispatchers to dispatch the management call-out crews in the same manner as regular field personnel. Examples are given of the management call-out list and of the intensive training schedule.

The management emergency crews were dispatched 115 times during the six-month period. The cost of overtime and standby hours totaled $22,050. The advantages of a cross-training program for any utility include improved productivity, better understanding of field operations by management personnel, and better overall emergency preparedness. The program also served to identify problems such as the need for better lighting equipment for nighttime call-outs, the need to improve the accessibility of necessary safety equipment, the presence of poor housekeeping and stocking of materials on some trucks, and instances of worn-out tools or equipment still in use.

The article clearly illustrates the advantages of personnel cross-training and would be very useful to utility managers in their efforts to establish a cross-training program.

113
Shawcross, John F., and Donald Atkinson. 1981. Increasing Rockport's Water Supply. Journal of the New England Water Works Association 96:337-352.

This article reports on the planning process to increase existing water supply sources for Rockport, Massachusetts, population 6,500, subject to extreme summer water demands due to tourism.

The emergency water plan consists of local actions taken to meet short-term shortage expectations and consists of diverting raw water from nearby brooks and gravel pits and imposing bans on outside use of water to reduce peak demands. Landowner opposition to easements and arguments for improving water conservation have delayed the adoption of a feasible long-term diversion project.

Implementation of the emergency water measures is claimed to be the reason for a water use reduction of 65 million gallons per year and a supply augmentation of 74 million gallons, but the factors contributing to this decline are not supported by specific data. There are no individual connection meters to measure time and quantity reductions across typical water use sectors, and it can only be assumed that reduction has occurred due to water conservation, a drop in the tourist trade, increased precipitation, or a combination of these factors.

The article provides insight into the importance of accurately identifying potential water emergencies.

114
Shultz, John G. 1982. Sporhase v. Nebraska ex rel Douglas: Diverting the Course of Western Water Law. South Dakota Law Review 28:122-144.

This paper comments on the impacts of the U.S. Supreme Court decision.

The western states' legal relationship with the water within their legal jurisdiction was affected in two general ways as a result of this case. The Court's decision to overrule a Nebraska statute permitting interstate reciprocity of groundwater was based on exportation, which promoted a barrier to commerce without significantly advancing the state's legitimate conservation and preservation interests. Thus, the Sporhase decision recognizes a federal interest in water regulation, an area that has traditionally been the sovereign domain of the western states. Water statutes prohibiting water exportation are now constitutionally suspect unless they explicitly serve a state's conservation purpose.

The consequences on emergency water planning are not discussed.

115
Skaff, Richard B. 1979. The Emergency Powers in the Environmental Statutes: A Suggestion for a Unified Emergency Provision. Harvard Environmental Law Review 3:293-325.

This article provides an analysis of the emergency powers of the Clean Water Act of 1977, the Safe Drinking Water Act of 1974, the Clean Air Act Amendments of 1977, and the Resource Conservation and Recovery Act of 1976.

The emergency provisions give the Environmental Protection Agency (EPA) administrator discretionary authority, unlimited by other provisions, to act in an emergency. In general, there are two requirements for the invocation of the emergency power. First, the administrator must receive evidence that a pollution source or combination of sources is presenting an imminent and substantial endangerment to health, welfare, or the environment (no single provision protects all three). Second, three of the provisions require that state and local authorities must not have acted to prevent or remedy the emergency; two of these provisions explicitly direct the administrator to consult these authorities. If these two requirements are satisfied, the administrator may bring an action for equitable relief on behalf of the United States in the appropriate federal district court in order to prevent or remedy the emergency. The civil suit may be brought to restrain any person "causing or contributing to" the pollution. Following a comparative analysis of the emergency provisions, the author raises unresolved questions regarding the emergency powers and demonstrates that a single emergency provision, incorporating the best characteristics of current provisions and covering any type of pollution emergency, would give the EPA administrator more effective authority to prevent and alleviate pollution.

The major themes of the emergency provisions include the scope of protection; provisions for interaction with state and local authorities; judicial interpretations of the imminent and substantial endangerment standard to invoke civil action; and other remedies, such as administrative orders and funded emergency assistance. Although the administrator has brought only four civil actions, the author indicates that the emergency powers have alleviated many pollution emergencies by compelling action from state and local authorities and voluntary compliance from the polluter.

The article provides a thorough, analytical examination of the pros and cons of using emergency provisions contained in existing environmental protection legislation to prevent or curtail pollution.

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Slafkes, Mark E. and Thomas J. Edwards. 1976. Emergency Water Allocation Literature: Sources and Retrieval. Emergency Water Allocation Project, Working Paper No. 4. Irvine: University of California.

This report serves as a guide to the many printed and computerized sources of data and abstracts, with special emphasis on topics related to emergency water allocation (EWA). An exhaustive search of the literature available in the United States revealed that very little had been published in the area of emergency water allocation problems; this report is offered as a guide to the literature search process.

Several California libraries are cited with full addresses and telephone numbers to facilitate access. The libraries were the EWA Project's most useful bibliographic referencing locations. Additionally, most of the computer searches were conducted through the University of California at Irvine (UCI) library services.

Computerized information retrieval systems allow the user to access computerized data bases, which usually offer three types of search capability: (1) custom search (customer-designed, individualized), (2) packaged search (predesigned), and (3) Selective Dissemination of Information (SDI), which is a periodic updating or "current awareness" service. Retrieval systems may access one or many data bases varying in size and content. Different organizations offering searches may cover the same data base under a different name; knowing the orginating institution of a particular data base helps to avoid duplication of efforts. Several retrieval systems are described with access information, including: Smithsonian Science Information Exchange (SSIE); National Technical Information Service; Oceanic and Atmospheric Scientific Information System (OASIS); Environmental Data Index (ENDEX); Water Data Storage and Retrieval System (WATSTORE). Several computer data bases are listed. The authors believe the term "collection" to be more descriptive than "data base" and distinguish between collections of data and collections of bibliographic information. Printed collections of data and bibliographies are also listed and described.

The conceptual strategies utilized in the development of a bibliography for the EWA Project involved either the inherent or relational qualities of a publication. Inherent qualities were associated with the ideas present in the work. Relational qualities were evident through membership in an easily defined class of written pieces, which included the author or publishing institution or a monograph's acquisition by an institution whose acquisition lists were available to the EWA Project. Relational qualities served as initial selection devices and inherent qualities as final selection devices. Two problems with inherent qualities were (1) the researchers had to conceptualize and reconceptualize the research problem to identify critical ideas and relationships and (2) the researchers had to determine how the developers and maintainers of various accession technologies found primary documents, described these documents, placed accession information in the data base, and provided for developing of the data base in order to determine if the data-base framework matched the researchers requirements.

The highly specific inherent qualities used in the final phase included (1) primary subject key words such as "water," "hydrology," and "San Diego"; (2) simple subsets of concern about water such as "water shortage" or "water conservation"; (3) logical intersections or unions of subsets; and (4) disaster or resource allocation problems that have similar human or physical qualities, such as "fuel shortages" or "food shortages." Relational qualities included (1) acquisition by an agency known to collect useful documents; (2) inclusion in a data base; (3) authorship by a known expert in a particular area; (4) references given by a particularly useful article or book; (5) use of citation searches; (6) shelf location and subject index; and (7) publications normally distributed by organizations concerned with activities relating to the research interests. The inspection of articles from particular journals was infrequently done; the researchers found this technique to be time-consuming and unproductive, compared to other relational techniques.

This report would be useful to any researcher initiating a substantial literature search.

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Smedberg, Raymond C. 1983. Emergency: Intrusion of Propane Into Water Mains. In Proceedings, American Water Works Association Annual Conference, pp. 9-14. Denver: American Water Works Association.

This paper details a case history in which propane gas was inadvertently injected into a water utility's distribution system. Bridgeport Hydraulic Company (BHC) is an investor-owned water utility serving a population of 350,000 in twelve Connecticut communities. On August 5, 1982, the utility received notification from the Trumbull, Connecticut, Police Department that the Trumbull Fire Department had discovered gas coming from hydrants. Initial field reports confirmed the presence of propane gas in the distribution system, and the utility's general emergency plan was activated. Various management personnel at the utility were immediately notified, as were the BHC Quality Control Laboratory and the Connecticut State Department of Health Services. BHC's Corporate Relations Department designated a media spokesperson, and the utility coordinated efforts with the Town of Trumbull emergency personnel and Southern Connecticut Gas Company (SCGC) personnel at an on-site emergency command center.

The SCGC owns and operates a propane plant in the area of the intrusion; at the time of the accident, SCGS personnel were purging a 30,000 gal. propane storage tank using water taken from one of the two private hydrants located on SCGC property through a 1 1/2" hose connected to the inlet of the tank. This violated the State of Connecticut Public Health Code and BHC Rules and Regulations pertaining to cross-connections with a public potable water supply, as well as BHC Rules and Regulations pertaining to the use of private fire hydrants. Standards established by the American Gas Association included no provision for protection of potable water supplies from cross-connections. Additionally, AGA standard procedures were not followed--the valve on the hydrant hose connection was opened while approximately 83 psig vapor pressure remained in the tank; the public water supply pressure was approximately 65 psig at the time. SCGC estimates indicated as much as 750 c.f. of propane may have been introduced into the water distribution system, or the equivalent of 2,000 lineal feet of water main. BHC's Quality Control Laboratory researched the nature and properties of propane gas and determined that propane is heavier than air, lighter than water, and approximately six percent soluble in water at 65 degrees F. Propane is not considered to be toxic but does produce a narcotic effect at high concentrations. The primary cause for concern was the possibility of ignition. During the emergency period, explosions and fires occurred at two residential dwellings, with no serious injuries or fatalities.

The utility's emergency response consisted of four phases. The initial problem was to identify the affected area and isolate the water mains in that area to contain the problem. The affected area involved approximately 8,600 lineal feet of 8-inch diameter, cement-lined, cast iron water main, and 85 customers, of which 73 were residential and 12 were commercial. All people in the affected area were evacuated and electricity, gas, and water services to the area were shut off. The second phase required that the utility fill and vent the water mains to force out the propane. Alternative methods were considered; due to the need to restore fire protection, the standard procedure of filling with water and venting through hydrants and air vents was chosen as the most expedient method. During the third phase, teams consisting of BHC and SCGC personnel, together with commercial plumbing contractors and a Trumbull police officer, went house-to-house to restore indiviual water and gas service, check and vent each water-using device and/or system, and relight gas pilots. Upon the completion of this phase, full service of all utilities was restored to the area. The fourth phase involved a continuous flushing and sampling program to monitor water quality. The Connecticut Department of Health Services established 1 ppm as the "no health effects threshold level." A five-day ban on using the water for drinking or food preparation was issued, with customers being supplied with bottled drinking water. The flushing and monitoring of the area continued for one month, at which time no traces of propane remained in the water.

Following the accident, provisions were made to disseminate information about the incident to the water and gas industries and to make provision in appropriate AGA manuals for protection of potable water supply. The potential for contamination of potable water supply through storage and handling of gases under pressure is great due to routine maintenance requirements and to local, state, or federal regulations requiring that such facilities be periodically inspected and tested, for the usual procedures for purging and pressure testing such facilities utilize either inert gas or water, with water being the preferred method. The Connecticut Section AWWA Cross Connection Control Committee requires that Connecticut water utilities annually inspect all consumer premises where gases are stored under pressure and the potential exists that tanks could be purged with water. A reduced pressure principle backflow preventer must be installed where a connection between the waterline and gas storage tank could occur.

The paper is very informative and effectively illustrates the need for cross-connection control among utilities.

118

Smith, Robert B. 1976. Water Supply and Distribution in Alaska. Journal of the American Water Works Association 68:5-7.

The author describes the effective adaptation of Alaskan water utilities to the extreme weather conditions of their area. The article is a review of the water supply systems of three Alaskan cities.

Local sources of water supply in Alaska frequently present problems. Sources may freeze in the winter; have heavy silt concentrations due to glacial drainage, making the water difficult to treat; or lack circulation and become contaminated, as do the pothole lakes that trap water with no inlet or outlet and permafrost below. Apart from the source of supply problems, the two major problematic factors affecting Alaskan water supplies are temperature and soil conditions, such as permafrost. Other problems include inaccessability of remote areas, freight costs, limited population, and financing. Many of the problems unique to this area require unique solutions, such as using dogsleds to transport large chunks of freshwater ice to remote villages needing water.

For many years, the city of Nome, 500 miles northwest of Anchorage, received its domestic water supply by tank truck, delivered to individual locations and sold by the gallon or bucket. The source of supply is a well located several miles from town. During the early 1970s, a buried, insulated main was constructed to pipe water from the well into the city. Summer supply in some areas was distributed by an above-ground pipe system. Much of the north, northwest, and interior areas of the state have permafrost underlying the surface.

Fairbanks is the second largest city in Alaska and is located 300 miles north of Anchorage in the central, or interior, section of the state. During the summer months there is a period when the sun never sets and temperatures are often in the 80s. During the winter the nights are very long and temperatures may range from -40 degrees F. to -65 degrees F. In early years, the city was served by a summertime above-ground pipe system which was drained each winter, while winter supplies were obtained from individual wells and bottled water sold for drinking. In 1954, the city developed an innovative approach to obtain year-round provision of water. A coal-fired steam generating power plant and a water treatment plant were built adjacent to each other along the banks of the Chena River. Wells drilled near the riverbank provided water for boiler and cooling purposes, which created a source of heat that could be introduced into the water supply system. Breakpoint chlorination precipitates much of the high organic content of the raw water before it is used for cooling. After the water is run through the condensers at the power plant, the waste cooling water is sent to the treatment plant at temperatures of 35F-36F. At the water treatment plant, conventional treatment by flocculation and rapid sand filtration prepares the water for distribution. Below a depth of six feet, the temperatures of permafrost tend to remain constant at 29F-30F, unaffected by seasonal freezing and thawing or extreme winter temperatures. Insulated steel water mains were laid at a depth of six feet, and the heat introduced into the water is controlled so that water temperatures remain at 35F-40F. Higher water temperatures could result in the thawing of the permafrost surrounding the pipelines, which would make the permafrost unstable and subject to seasonal fluctuations. Both the main distribution lines and the individual services were designed to permit constant circulation.

Anchorage, the largest city in Alaska, is located in the south-central portion of the state and is the economic, cultural, and distribution center for Alaska. Temperatures may range from a low of -35F to a high in the mid 80s, although the extreme temperatures are rare. Anchorage is served by two large water utility systems; one is a municipal system and the other is investor-owned. A number of smaller utilities provide water for limited areas, and the two military bases have their own supply and distribution systems. Although permafrost is not found in this area, winter problems include temperatures that remain below freezing for most of the season and seasonal frost penetration which may extend to depths of ten feet. The most severe problems are usually encountered in paved areas. The sources of water supply are predominately deep wells, although one clear water stream flows out of the mountains and through the Anchorage area.

During the winter months, the low temperatures of water being introduced to the system created severed freezing problems. In the 1950s the city began mixing deep-well water with the stream supply to raise the temperature by a few degrees, which sharply reduced incidents of frozen services. To escape the effects of seasonal frost penetration, area utilities have adopted a standard minimum depth of ten feet of ground cover over mains and services. Ductile iron has proven to be the most desirable pipeline material, although copper tubing is utilized for services up to two inches. Utilities are also careful to build electrical conductivity into the system so that electrical thawing may by utilized when frost penetration threatens services. In situations where excavation of pipeline is required, the frozen ground is thawed at the point of excavation by forcing live steam into the ground. Fire hydrants are particularly vulnerable to freezing temperatures, and the utilities avoid locating service trenches near hydrants to prevent the possibility of on-property damage if a break should occur.

The author provides clear, useful descriptions of the adaptation of water supply systems to extremely low temperatures.

119
Stephenson, J. M. 1964. Earthquake Damage to Anchorage Area Utilities--March 1964. Technical Note N-607, U.S. Naval Civil Engineering Laboratory, Fort Hueneme, California.

This brief report describes the nature of damages suffered by power, gas, water, and other utilities in Anchorage during the 1964 Alaskan earthquake. The information presented in the report was obtained by the author in Anchorage between April 3-13, 1964, one week after the event.

During the first week following the disaster, the cost of repairing the damage to utilities in Anchorage was estimated to be within the range of $5 to $8 million. Water supply sources were severely affected by the quake. The flow of Ship Creek, the major source of raw water, was temporarily reduced due to cracks and fissures in the earth. One city well was lost and three were partially damaged. At Fort Richardson, one well was disabled.

The water distribution system, comprised of either cement asbestos, cast iron, or wood stave pipe, was completely drained by numerous breaks resulting from the earthquake. About 60,000 feet of 4-inch aluminum pipe was laid on top of the ground to deliver water to one area of the city where the cement asbestos pipes were badly fractured. However, about 80 percent of the system remained intact, and ten days after the earthquake, all water was drinkable.

This report offers a concise inventory of the impacts of a major earthquake on area utilities.

120
Stone, Judy. 1980. Hurricane Frederic: Protection in the Aftermath. Security Management 24(2):22-28.

This article describes the experiences of the Alabama Power Company's security department in southwestern Alabama following Hurricane Frederic in September, 1979.

Following the hurricane, approximately 150,000 customers were without power in the Mobile area alone. Over 2,100 crewmen from several southeastern power companies worked to restore power to the area, and over 100,000 tons of materials were trucked in for use in the restoration effort which lasted 20 days. The Alabama Power Company (APC) ordinarily maintains one security employee, a resident investigator, in the Mobile area. Immediately after the storm seven additional APC security advisory personnel were dispatched to Mobile and stationed there throughout the three-week restoration period. The majority of the proprietary guards employed by APC are stationed at a nuclear plant and cannot be reassigned, even under emergency situations. Due to the extensive damages nearly all guard personnel employed by local contract guard agencies had been assigned already to patrol local business districts. By reassigning APC personnel and hiring 16 contract guards, the power company was able to assemble 34 security guards to patrol all APC materials and assets within the Mobile area. The sparse security force was assisted by a 7:00 p.m. area curfew and by close cooperation from the police and National Guard.

During the restoration period, the primary objectives of the APC security department were (1) to patrol areas where a lot of valuable salvage was on the ground; (2) to coordinate deployment of guards to strategic locations, particularly sites where vehicles, materials, and supplies were stored and distributed; and (3) to protect damaged company buildings and their contents. Security personnel operated (1) to guard the company from additional losses; (2) to protect company personnel and their possessions; and (3) to relieve operating personnel from anxiety over loss of salvage or tools and equipment so that they could concentrate on restoration activities. The latter is particularly important; under emergency conditions, the replacement of stolen equipment is usually impossible, and crews cannot restore service without the necessary equipment. During the three-week restoration period few losses were experienced due to theft; 14 arrests were made, several of which were successfully prosecuted.

The Alabama Power Company learned several lessons in the provision of security under emergency situations: (1) security activities must be coordinated with all other company operations; (2) the security department and uniformed guards should have an exclusive radio frequency for use anywhere within the system to avoid mutual interference with other emergency operations; (3) security personnel should work with police in making arrests to augment overburdened police capabilities; and (4) large or valuable salvageable materials should be marked through special methods to permit future identification as company property.

The article effectively illustrates important considerations in planning for utility security under emergency conditions.

121

Teller, Joe P. 1961. Disinfection of a Distribution System after Disaster. Journal of the American Water Works Association 53:1403-1405.

This article reviews the case history of a flood in Texas to illustrate some effects of disasters on water utilities and suggests measures to facilitate the restoration of service.

In Port Lavaca, Texas, 30 inches of rain fell on already saturated ground within a 24-hour period. The ensuing flood washed out several main waterlines, plugged up sewer lines, and flooded homes. The washouts occurred so rapidly that the water system was completely exhausted before control valves could be closed. Motors on pumps in the utility's well field shorted out in the rain, and electrical power to the well field was interrupted. Roads leading to the well fields were impassible, with two feet of water standing in some areas. Hauling and distributing emergency supplies to city residents required enormous outlays of manpower and equipment.

Due to the intrusion of storm waters into the distribution system, the entire system required disinfection. After repair work had begun on the well fields and broken lines, a portable chlorinator was used, with a 0.5 mil gal storage tank as a point of contact, to chlorinate water to 200 ppm. The stored water provided the first supply available for fire fighting in over 36 hours. Handbills, radio and television announcements, and public address trucks advised residents to close all taps and report leaks to the water plant. The system was flushed, and residuals of 150-200 ppm were maintained for 24 hours, with periodic decreases in the dosasge rate until 1-10 ppm remained in the system. The system was again flushed at the end of 24 hours and on the third day after the flood. All possible means of communication were utilized to urge residents to conserve water throughout the emergency. Most of the inquiries made to the water department concerned the disinfection of private wells, for which calcium hypochlorite was provided, and the cleaning and disinfection of private homes. Despite known contamination of several parts of the distribution system, there were no incidences of waterborne disease.

Recommendations for utilities to increase emergency preparedness include (1) the maintenance of an up-to-date map of the distribution system; (2) the maintenance of adequate emergency power equipment that is periodically tested to maintain readiness; (3) the stockpiling of equipment and supplies, particularly materials with free chlorine available; (4) the avoidance of complacency in emergency planning so that materials and personnel are maintained in a state of constant readiness; and (5) the assurance of safety by implementing disinfection if there is the slightest possibility of contamination.

The article effectively illustrates the importance of emergency planning.

122

Trelease, Frank J. 1974. The Model Water Code, the Wise Administrator, and the Goddam Bureaucrat. Natural Resources Journal 14:207-229.

This paper critically reviews A Model Water Code, by Frank Maloney et al., and compares riparian law, prior appropriation law, and A Model Water Code.

The author provides criticism of A Model Water Code because it substitutes a permit system of administrative control over private water users in lieu of the riparian property rights which now govern them. The expected results of "bureaucratic" discretion during water shortages or emergency situations are not clear, for no guidelines are established to steer the exercise of this discretion. Permits will be classified by source, method, and use and may be subject to temporary reductions in total water use, to restrictions on selected classes of permits, to revised permit conditions, or to suspension of permits. In an emergency, orders may be issued to require apportioning, rotating, limiting, or prohibiting water uses.

Thus, the legal uncertainties of riparian rights are substituted by administrative uncertainties. In contrast, the author indicates that prior appropriation law, although criticized for placing the burden of physical uncertainties on the junior appropriator, provides the appropriator with alternative choices at the time the water right is requested. The appropriator can gauge the worthiness of his venture in the event of a future water emergency that may prohibit water use and can consequently decide to invest his or her capital elsewhere.

This article carefully delineates the positive and negative aspects of riparian law, prior appropriation law, and A Model Water Code and strongly implies the importance of documenting and negotiating agreements of emergency water plans before such an event occurs. Liability disputes arising from actions taken during water emergency situations may be reduced if water users know in advance what to expect regarding water use restrictions and are thus able to prepare for restrictions accordingly.

The article would be useful to emergency planners in ascertaining the legal consequences of emergency water planning.

123

United Nations Economic Commission for Latin America and the Caribbean. 1985. Damage Caused by the Mexican Earthquake and Its Repercussions upon the Country's Economy.

The purpose of the report is to provide a rapid assessment of the impacts of the Mexican earthquakes of September, 1985. The paper was published one month after the disaster and contains initial impressions and estimates of earthquake consequences.

The earthquakes are described and accounts are given of actions taken immediately after the disaster. Regarding water supply, pipelines carrying drinking water to the Federal District were broken in several places and numerous ruptures occurred throughout the distribution system. Restoration efforts began immediately after the disaster, and information on protective health measures was disseminated to the public.

A brief summary of the earthquakes' impacts on the water supply system is given. The earthquakes damaged two of the main aqueducts carrying drinking water to the Valley of Mexico, resulting in the loss of approximately 10 percent of the total supply. Ruptures occurred in the secondary aqueducts and in the distribution system within the metropolitan area. Water shortages necessitated the rationing of services in several districts of the capital. As this report was being prepared, there was not yet word on the nature of damages to water supply systems in the hinterland. Within fifteen days of the disaster, all ruptures in the main aqueducts had been repaired, but less than half of the distribution system breaks had been located. Rationing continued in the central and outlying areas, with tanker trucks providing water to the stricken areas. Estimates for restoration of services range from six weeks for 90 percent restoration to three months for full restoration of services. No information was available regarding damages to deep drainage and sewer systems, although it was assumed that serious breaks did occur. The cost of repairing the two main aqueducts was estimated to be 2 billion pesos, with repair of distribution system breaks estimated to be 5 billion pesos. These estimates were based on a valuation of the manpower used to repair 40 percent of the leaks and on a ratio of 1:2 for the cost of the materials used in the repairs. The potential loss of earnings due to the disruption in service was estimated to be 600 million pesos, although social costs are much greater.

Although written only two weeks after the earthquakes, the report offers a good description of the disaster itself and provides a strong sense of the various impacts of the earthquakes on the community.

124

United States Army Corps of Engineers. 1985. Emergency Water Hazard Analysis for Selected Study Areas in Ohio. Draft Report, USACE Emergency Water Preparedness Program. Prepared by U.S. Army Engineer District, Pittsburgh.

This study explores the specific types and impacts of hazards that create water emergencies and presents water hazard analysis procedures that yield a numerical score with which water managers may prioritize their emergency water planning activities.

Hazard is defined as a potential event or circumstance that presents a threat to life and property. Hazard analysis is defined as the identification of the relationship between and among hazards and the vulnerability of life, property, the environment, or social and economic activity to the actual or potential impact of the hazards. Finally, emergency water hazard analysis is defined as the identification of the relationship between and among those hazards that adversely affect water sources and water facilities. This study is part of a six-year emergency water preparedness program that will produce a detailed, comprehensive plan of responsibilities, procedures, and actions for the Corps and other federal and state agencies regarding water management under various types of emergencies. Two general types of emergencies are considered. Civil emergencies, as related to water, include natural and man-created events leading to a shortage of water or contamination of water and are usually local or regional in extent. National emergencies include situations arising as a result of increased world tensions, preparation for war, or the conduct of a war and are associated with a war mobilization effort and civil defense preparations.

The study focuses on six study areas within the state of Ohio; brief socioeconomic descriptions are given of each. Primarily metropolitan areas, the study areas represent, to the maximum extent possible, manufacturing/industrial centers of national, regional, and local significance. The rating and scoring system used in this analysis is generally based on guidance contained in the Federal Emergency Management publication, "Hazards Analysis for Emergency Management (Interim Guidance)." The four criteria used are (1) history--the record of occurrences; (2) vulnerability--all people and property that may be adversely affected; (3) maximum threat--the worst case scenario, assuming both the greatest event possible and the greatest impact; and (4) probability--the likelihood of an event, usually expressed as the number of chances per year that an event will occur. Each criterion is assigned a descriptive rating of either low, medium, or high. Vulnerability, maximum threat, and probability are also assigned a second rating for each hazard to indicate the presumed conditions during a national emergency.

For the rating system, independent judgments are used. (1) History: "low" = 0-1 occurrences per 100 years; "medium" = 2-3 per 100 years; "high" = more than 4 per 100 years. (2) Vulnerability: "low" = less than 1% of the total number or value is exposed or affected; "medium" = 1%-10% of the total number or value; "high" = more than 10% of the total number or value. (3) Maximum Threat: "low" = less than 5% of an area is seriously impacted (fatalities or complete destruction of property); "medium" = 5%-25% seriously impacted; "high" = more than 25% seriously impacted. (4) Probability: "low" = less than 1 in 1,000 chances per year of occurrence; "medium" = between 1 in 1,000 and 1 in 10; "high" = greater than 1 in 10.

The scoring system involves assigning each of the four criteria a numerical value, depending on the rating made: low = 1 point; medium = 5 points; and high = 10 points. Some criteria were judged to be more important than others; a weighting factor was established to balance the total scoring: history = 2 units; vulnerability = 5 units; maximum threat = 10 units; and probability = 7 units. A composite score for each hazard is determined by multiplying the score value assigned to each criterion by its weight and then summing the four totals.

Fifteen water hazards are individually analyzed. For all hazards selected, the primary or secondary effects could result in a shortage of water, contamination of water, or damage or destruction of water facilities. The initial objective was to develop the various hazard ratings for each study area. An accurate evaluation for each study area would require extensive data collection and analysis; time constraints necessitated an aggregate approach. Therefore, the hazard ratings obtained are applicable to the six study areas as a group. If dissimilar area characteristics would produce rating differences, the highest (most serious) rating was generally chosen. Each hazard is categorized as either a general or national emergency; the effects of the hazard on water are discussed; and a brief description of each criterion rating is given. The results are listed here, ranked progressively by score, with a second score listed in parenthesis to indicate the hazard rating under the presumed conditions of a national emergency. The hazards are civil disturbance/riot = 44 (72); extreme winter cold = 52 (52*); dam failure = 64 (92); nuclear power plant accident = 84 (147); landslide = 92 (92*); nuclear material spill = 112 (147); severe storm = 120 (120*); hazardous waste contamination = 155 (240); terrorism and sabotage = 159 (162); earthquake = 162 (162*); nuclear attack = 187 (222); and flood = 205 (205*), tied with hazardous material spill = 205 (240). An asterisk beside the second score indicates an unchanging rating, which means that the combination of a hazard with a state of national emergency would increase neither the vulnerability of property, facilities, and people nor the percentage of area seriously impacted (maximum threat); nor would it increase the probability of occurrence.

This study introduces a means by which the hazardness of an area with respect to water supply can be identified and quantified. This water hazard vulnerability analysis technique could be useful to water resource managers and to emergency managers/planners.

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Urbach, G.; R. Schinzinger; and H. Fagin. 1977. Emergency Water Allocation: Restoration of a Water Distribution Network. Emergency Water Allocation Project, Working Paper No. 9. Irvine: University of California.

This is the third in a series of four papers describing a project that assisted water districts in San Diego County, California, in the formulation of water allocation and system restoration procedures to prepare for sudden emergencies. This paper addresses the rapid restoration of water service in a system which has incurred physical damage and discusses different allocation policies from which may be selected an appropriate set which will match the pattern of disruption.

The systematic restoration of the physical water distribution system can be organized into four steps:

(1) Preparedness measures--awareness of vulnerability, education, communication and coordination, and contingency guidelines.

(2) Information gathering- problem identification.

(3) Restoration management during emergency--problem verification, alternative restoration measures, alternative sequencing of tasks, and restoration priorities and objectives.

(4) Implementation of restoration measures--activation of plan, reports, and evaluation.

The activities within the steps are interrelated and the process may be iterated as needed during the emergency period. The paper focuses on restoration management during emergency. Alternative restoration measures may be grouped into three categories--temporary measures (e.g., water trucking), exclusion measures (e.g., evacuation of water users), and permanent measures (e.g., repair)--that differ by degree of permanency. The sequencing of restoration activities can follow several possible priority schemes. The feasibility of each possible sequence can be determined by constraining the alternatives with respect to (1) component capacity, (2) operational considerations, (3) network topology, and (4) resource availability.

Decisions regarding restoration priorities and objectives must be formulated by establishing a measure of effectiveness against which various strategies are examined. The measure of effectiveness will frequently be related to utility constraints such as system capacity, time, or money. However, objectives must consider other systems which interact with the restoration system. A primary interaction is that between the utility and its customers. User sensitivity to disruptions in service produces three types of criticalities: (1) those resulting from clustering (density of use); (2) those resulting from special uses (e.g.; hospitals); and (3) those resulting from the nature of the disruption (e.g., disaster accompanied by fire). Although following a distinct objective and satisfying critical needs may be contradictory, satisfactory restoration strategies are frequently obtained by ranking tasks in an ordered sequence; while perhaps not an optimal solution, this permits the application of sensitivity analyses and optimal resource allocation procedures.

The development of a fire flow strategy is presented to illustrate the formulation of physical constraint sensitivity models and resource allocation models. Four allocation schedules suitable to water system models are (1) maximum satisfaction of priorities, (2) maximum utilization of resources while minimizing disturbance of priorities, (3) minimum time of restoration while minimizing disturbance of priorities, and (4) job shop scheduling. Allocation models appropriate to each are formulated.

The paper provides practical methodology for systematically evaluating, constructing, and implementing water system emergency restoration plans. The authors note that the presentation [illegible] readily applicable methods required certain shortcuts: (1) the use of heuristic procedures where the combinatorial nature of alternative strategies coupled with computational limitations preclude the application of exact algorithms; (2) the use of objective functions describing a single criterion where multiple criteria might be more appropriate, although the trade-off between criteria and constraints invariably results in some suboptimization; and (3) the employment of the assumption that the emergency will not change its character during the duration of the water system's disruption--outcomes of the restoration activities were assumed to be known.

126 Valcour, Henry C., Jr. 1979. Pumping Station Reliability. In Proceedings, AWWA 1979 Annual Conference, Part 1. Denver: American Water Works Association.

The article explores the need for, and provision of, pump station reliability. Reliability is defined, various reliability requirements are examined, and the design and maintenance of reliable pump station components are discussed. The author proposes a universal classification system of reliability.

The reliability of pumping stations is defined as the ability of the facility to provide service at an acceptable level of interruptions in spite of abnormal conditions, and the ability of the facility to provide continuing and long-term operation without the need for frequent repairs, modifications, or replacement of components. Water-pumping stations are utilized for a variety of reasons, ranging from low lift stations to in-line boosters, and the degree of reliability required is different for each. Once the degree of reliability required is established, steps must be taken to assure that degree of reliability. Regulatory requirements pertaining to pumping stations are very broad in nature and rarely include reliability criteria. The Insurance Services Organization and their fire protection rating system are more specific in their regulation of reliability features, such as maintaining design rate of flow with the largest pumping unit out of service. Pump station design should consider disaster situations as well as environmental factors such as excessive amounts of salt air near ocean installations and mold and bacteriological growth in tropical climates. Backup features should be provided for all essential systems, especially less visible but still critical components such as [illegible] emetering [illegible]. Reliability considerations should apply not only to individual components but to subsystems as well.

In some situations, such as [illegible] applications, the amount of downtime that can be tolerated is virtually none. Elsewhere, as in large water systems with several sources of supply, reliability requirements are not as great. At the heart of the determination of reliability requirements lies the issue of the [illegible] required [illegible] provide various levels of reliability. Three basic means of improving station performances are (1) the use of more conservatively stressed components; (2) installation of built-in or backup spares; and (3) isolation or segregation of components or systems. In evaluating reliability needs, factors to be considered include (1) the practical availability of alternative sources of supply; (2) the anticipated results of longer periods of station shutdown; (3) health and welfare impacts on station outages; (4) the availability of qualified operating and maintenance personnel; and (5) the availability of replacement components. Other issues contributing to reliability include preventive maintenance, catastrophes that result in corrective actions and thus strengthen systems, ambient heat conditions, dehumidification, upstream and downstream conditions, and unique situations such as systems located in war zones. In planning for pump station reliability, attention must be given to design, standards, specifications, and finances. The author proposes a classifications system of four grades of reliability, and delineates reliability criteria, which are (1) facility criteria, (2) process criteria, (3) component criteria, and (4) maintenance criteria. Three brief case histories are offered as examples of differing reliability requirements.

The article is informative and would be useful to water utility managers in their efforts to evaluate the reliability of pumping systems.

127

Wade, Jeptha A., Jr. 1959. Organization of a Master Disaster Plan. Journal of the American Water Works Association 51:163-170.

This article discusses an emergency operations plan maintained by a large water utility.

The California Water Service Company (CWSC) consists of 19 units or districts located throughout the state serving a total population of 840,000. Corporate headquarters are maintained in San Jose, where a central management team is available to all units. Over the years, CWSC has faced natural disasters, such as earthquakes and floods, and has developed a master disaster plan which is widely distributed and immediately available at all levels of the company. A copy of the master plan is kept in each company vehicle, along with self-stick signs to identify the vehicle in the event of an emergency.

The four steps to be taken in the event of an emergency are (1) decide immediately who is to be in charge; (2) establish headquarters, at which the chief authority is available at all times; (3) make a survey of the damage before taking corrective actions and isolate the damaged areas to preserve storage resources; and (4) get accurate information of the situation to all other interested agencies. CWSC's disaster plan contains an established pattern of operation, which clearly indicates the direct alternates to the nominal local authority in the event that the nominal authority is unavailable. Once identified, the chief authority is not to leave headquarters. A survey of the disaster is made using all available personnel, who are instructed not to make repairs but to relay survey information to headquarters as rapidly as possible. This allows a priority allocation of repair. Before repairs are initiated, the damaged portions of the system are isolated. In activating liaisons with other agencies, only one person is designated by the chief authority to disseminate information.

Communications are vital in emergencies. CWCS has radio equipment in 22 fixed stations and over 50 mobile units that create an emergency communications network by relaying messages from point to point. Two mobile radio units are maintained in the statewide traveling superintendent's car; one is hooked into the company system and the other is tied into the standard telephone company system. Walkie-talkie or field communication units operating on the company frequency are also maintained, and CWSC has issued written instructions to each district to establish communications with local ham operators to faciliate their use in an emergency. The company also maintains a statewide message center on a 24-hour, 7-day-a-week basis, which acts as a clearinghouse for tracing supervisory personnel.

Each basic operating unit maintains a stock of replacement parts and chemicals. Records of emergency stock indicate types and quantities of emergency stock and where it is stored. The preservation of company records is an important issue in emergency planning. Guidelines for determining which records to preserve are (1) their importance to immediate operations, (2) the intrinsic value of the records themselves, and (3) the value of the records for establishing ownership of other items. At CWCS, full-size copies of each system map and block plot detail sheets are made each year and maintained at a city designated as an alternate disaster headquarters. Monthly financial statements are filed in full size for a period of five years, and important ledgers are microfilmed. The costs and procedures required for such preservation must be evaluated; the burden of being safe from a disaster should not impair day-to-day operating efficiency.

The CWSC plan has been successfully implemented. A 1952 earthquake in Bakersfield destroyed two elevated tanks and knocked out well pumps without any of the customers being aware of an interruption in service.

This article contains many valuable illustrations of emergency planning procedures that could be very useful to water utility managers.

128
Wang, Leon R. L., and Holly A. Cornell. 1980. Evaluating the Effects of Earthquakes on Buried Pipelines. Journal of the American Water Works Association 72:201-207.

The authors analyze procedures for evaluating stresses in buried pipelines to aid water utilities in earthquake resistant design of distribution systems and in evaluation of existing systems. The article reviews geological information on earthquake forces and water systems engineering.

During the 1971 San Fernando earthquake, nearly all pipelines crossing a major fault break ruptured at or near the fault crossing. During the 1906 San Francisco earthquake, almost all major pipeline breaks occurred in an area of lateral spreading of the ground. An understanding of the effect of earthquake forces is essential to improving the earthquake resistance of water supply facilities. Design of pipelines crossing faults or in areas where landslides occur is a difficult problem because forces and movements cannot accurately be predicted. One procedure requires that a flexible connection be provided at each side of the fault and that the pipeline be laid either inside a large carrier pipe or embedded in a material that can move or deform without breaking the pipeline itself. Landslides or liquefaction are even more difficult to predict than movements at known faults; designing pipelines to withstand all possible damage from such occurrences is nearly impossible. It is best to avoid areas having steep slopes and soft- or fine-grained soils; if avoidance is impossible, the best response is to provide adequate valving and as much flexibility in the pipe system as possible in the hope of reducing breakage. Unlike building codes, there are no codes for the design of buried pipelines to resist seismic loads.

It is possible to make a reasonably complete investigation of an existing water system to establish its vulnerability to earthquake damage. The procedural steps involved are (1) a review of the geology and available earthquake risk information to develop an approximation of the probable earthquake intensity; (2) a review of the underlying soils and geologic structure to indicate vulnerable areas; (3) obtaining approximate estimates of the ground velocity and the wave propagation speed from the United States Geological Service, the state, and other sources; (4) making an approximation of the earthquake stresses and joint movements from the information on analysis of pipelines subject to seismic forces to indicate where the system is vulnerable and what type of failures might occur due to wave propagation effect; and (5) a review of possible faults, slide, and liquefaction areas to point up those parts of the system that are susceptible to that type of damage. This general analysis of stresses in buried pipelines will greatly facilitate the design process as well. System design should proceed without consideration of earthquake and then be reviewed for its earthquake resistance, with vulnerable areas adjusted whenever possible. The authors conclude that the development of analytical methods to determine the strain, stress, and joint movement in pipelines is sufficiently advanced to permit reasonable approximations to be made for almost any system, type of pipe, and installation.

The article is concise and informative and illustrates a useful approach to improving the earthquake resistance of water distribution systems.

129
Water & Sewer Works. 1976. Emergency Planning for Water Utilities. Water & Sewer Works 123(4):80-81.

This article is designed to highlight the structure of an emergency operations plan. The outline of an emergency plan issued by the Texas Water Utilities Association provides an illustrative example.

When preparing a documentary emergency operations plan, most utilities can utilize a similar format. The basic structures are the same; the complexity will vary from system to system. The cover sheet details the utility's name and responsible authority, the date of the most recent revision, and the types of emergencies considered during plan formulation. A statement of operational authority establishes the authority of the plan for use in emergency situations. The text describes the responsibility of the utility for providing water service in specific emergency situations. The first responsibility is to establish and staff an Emergency Operations Center. Following the description of the Emergency Operations Center, each operating area of the utility has a statement of responsibility and duty, including the operating procedure for the emergency situation, the names of those in charge, the location of the Emergency Operations Center, and an alternate location to be used if the primary site is inaccessible. Specific operating instructions should be noted; specific responsibilities assigned to central office personnel, distribution system, production system, and pumping plant units can be included in the plan itself or listed in appendixes. Detailed instructions for each functional unit will usually be maintained at each physical location where personnel will be assigned during the event.

It is vital that the plan contain an organizational chart that details reporting procedures and relationships to other agencies, as well as a chart of the utility's managerial hierarchy. This will ensure that operations can be carried out if key personnel are unable to reach their assigned duty stations. The appendixes contain most of the procedural elements of the plan. Emergency Operations Center personnel should be familiar with each appendix. An outline for detailing the plan is given.

Portions of the Contingency Plan for Survival and Operations for Hurricane Conditions and Disasters of the Corpus Christi, Texas, Water Division are offered as examples of emergency plan design. The instructions within the plan are based on three conditions. Condition III is declared by the director of Public Safety and/or Civil Defense director when the National Weather Service indicates the possibility of a landfall within thirty-six hours close enough to cause damaging winds or tides in the city. Condition II is declared by the mayor or city manager when the course of the hurricane has been established and there is an NWS suggestion of a landfall within eighteen hours close enough to cause damaging winds or tides. Condition I is declared by the mayor or city manager when damaging tides or hurricane-force winds are imminent. Condition III results in notification of all personnel on a standby basis. Condition II requires that operating personnel complete arrangements for their families' safety and prepare to report immediately for duty when called. Supervisors are to prepare for the worse possible conditions.

The article offers clear, specific recommendations for the arrangement of a water utility emergency operations plan.

130

Wedeman, John D. 1953. Establishing Emergency Operating Procedures for Water Systems. Journal of the American Water Works Association 46:514-516.

The author presents guidelines for the development of an emergency operations plan for water utilities.

An emergency operations plan is defined as a plan providing for prompt action in an orderly manner to prevent or mitigate the damage of accidental disaster. In addition to increasing emergency preparedness, the analytical examination of an organization that is necessary to the emergency planning process may improve normal operations as well. Emergency plans should be based on the potential causes and effects of emergencies and the resources available for response to emergencies. Potential problems include power failure, water plant failure, structural failure (dams, pipelines, storage tanks), contamination (mineral, biological, radiological), flood, and drought. Floods and droughts may require separate engineering studies if the potential for major emergencies is great. A study of available resources would include (1) a thorough description of the water works; (2) operating guides; (3) policies of the organization; (4) the organization itself; and (5) pertinent laws and ordinances. The analysis of operational procedures should reveal areas of vulnerability that require correction as well as highlight the location of surplus personnel that may be shifted to other duties during emergency situations.

Potential emergencies should be classified according to imminence and seriousness, using such terms as "immediate" (no time for preparation), "impending" (allowing a brief period for preparation), and "remote" (ample time for careful planning). Each type of emergency should be classified as "major," "limited," or "minor," with each term being precisely defined according to local conditions. An emergency plan should provide for maximum utilization of personnel. Alternates should be provided for all key supervisory jobs, and alternates or assistants for minor supervisory jobs. Retired former employees may often be used successfully as alternates. In assigning emergency duties, specific descriptions should be given of the scope of responsibility and degree of authority appropriate to each. A liaison plan should specify the extent of support that can be depended on from other departments of the local municipality, from adjoining municipalities, and from commercial enterprises. A loose-leaf format facilitates the periodic updating of the emergency plan. The essential items in an emergency plan are (1) classification of emergencies with definitions of each category; (2) organizational structure of the utility; (3) plan of action for each emergency category; (4) liason plans for civil support and for commercial support; and (5) complete listing of normal operating procedures.

The article provides clear, concise information on the emergency planning process.

131

Westgarth, Warren C. 1981. Field Management of Hazardous Spills. Journal of the American Water Works Association 73:350-354.

This article summarizes the difficulties of protecting water supplies from accidental contamination and lists resources available to assist water system managers in planning and response.

The author notes that the possibility of contamination exists with virtually every water source currently in use in the United States. Many severe contaminations can be attributed to chemical spills resulting from transportation or transmission accidents. The possibility of intentional contamination must also be considered. For these reasons, each utility should develop an emergency response plan. The Oregon accident response system is offered as an illustration. The Oregon system emphasizes local responsibility for policing and controlling the immediate emergency; state agency responsibility for notifying others, for formulating secondary emergency decisions, and for initiating cleanup; and federal agency authority in the statutory responsibilities of the Environmental Protection Agency, the Coast Guard, and the Department of Transportation.

In describing state-of-the-art response capabilities, the author discusses the Chemical Manufacturers' Association program (CHEMTREC); the National Agricultural Chemicals Association (NACA); and the Chlorine Institute (ChlorRep). Private cleanup companies have evolved and are becoming more skilled. Local police, fire fighters, medical emergency personnel, and rescue service personnel are being trained to handle the immediate emergency, while state police and other state personnel are important to on-site response efforts.

The article provides useful information on resources available to assist water system managers in preparing for, and responding to, a hazardous materials spill.

132
Wilhite, Donald A., and Deborah A. Wood. 1985. Planning for Drought: The Role of State Government. Water Resources Bulletin 21:31-38.

This paper focuses entirely on drought emergency water planning and presents the results of a 1982 survey of all states to determine the status of drought planning.

Of the states surveyed, at least 37 were reported as not having initiated drought-planning efforts, although drought frequencies, as represented by the Palmer Index, are shown to have extreme values of 4.0 in many of these states as much as 10 percent of the time (period 1931-1978). A review of selected state drought plans for Colorado, South Dakota, and New York is given. The plans are shown to differ based on each state's unique water supply and management problems and the consequent impacts of drought emergency plan implementation. In each of the three states, an organizational structure has been created to coordinate the assessment and response activities of state and federal agencies.

The article effectively illustrates the potential of formal water resources planning for alleviating the impacts of water shortage. The presence of a drought emergency plan may facilitate the structure of an all-encompassing water emergency plan, provided that the incentive and support to do so can be generated by local state or federal initiatives.

133
Youd, T. Leslie. 1978. Major Cause of Earthquake Damage Is Ground Failure. Civil Engineering-American Society of Civil Engineers 17:47-51.

The author has investigated ground failures and other effects of several large earthquakes in order to evaluate the potential of an earthquake to cause ground failure, the danger a failure would pose, and measures for preventing or avoiding the danger. Four general types of failure causes are presented: (1) liquefaction including lateral spread, flow failure, and loss of bearing capacity; (2) strength loss in sensitive clays; (3) seismic shaking of steep slopes including rock falls and slides and shallow debris slides; and (4) failures caused by shaking of moderate slopes.

Most earthquake-induced ground failures are caused by liquefaction, by strength loss in sensitive clays, or by soil and rock slides on steep slopes. Lateral spreads caused by liquefaction usually sever pipelines and other utilities built on or across the spread. For example, every major pipeline break in San Francisco during the 1906 earthquake was caused by lateral spreading movements not greater than a few feet. Although there are techniques available for stabilizing the ground, the susceptible areas are usually too extensive for economical stabilization. Major damages to lifelines during the Alaska earthquake were due to five large translatory landslides resulting from the loss of strength in sensitive Bootlegger Cove clay in Anchorage. That soil contained clay layers with sensitivities between 10 and 40 (the ratio of the strength of an intact specimen of soil to the strength of the same soil specimen after large shear deformation or remolding).

Other types of ground failure which have destructive effects on water supply facilities are the failures of steep slopes such as rock and soil falls or slides which may change into fast-moving avalanches. Soil and rock not containing liquefiable sands or sensitive clays rarely fail catastrophically on less than 50 percent slopes; however, up to several feet of displacement may occur on some slopes, easily damaging water transmission and other facilities.

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APPENDIX B:

ALASKAN CASE STUDY

ALASKAN CASE STUDY

INTRODUCTION

Purpose

The Alaska case study has been prepared in support of the analytical bibliography in order to highlight the lessons learned as a result of the great Alaskan earthquake of 1964 that might be applicable to other events and other disasters. The specific study objectives are:

(1) How the event impacted water supply systems

(2) What pı ɔlems were encountered in trying to develop an emergency distribution system immeaiately following the event

(3) How the local community views emergency water planning now versus prior to the 1964 earthquake.

Approach

The approach to answering these questions was twofold. First, the research team reviewed published reports prepared in the aftermath of the disaster in order to compile all descriptions relevant to water utilities. Second, a telephone survey of about 20 individuals representing decision makers, planners, and engineers in Alaska was conducted in order to determine the present status of emergency water planning in the area.

The initial section which follows is organized according to the sequence of events and activities of the 1964 disaster with a particular focus on engineering features of water supply systems and emergency response and restoration of water supply. The subsequent sections introduce a longer perspective in order to analyze the impacts of the earthquake on the emergency planning environment prior to, immediately after, and 22 years after the event. In conclusion, the lessons learned are discussed.

THE ALASKA EARTHQUAKE OF 1964

Characteristics of the Event

The 1964 Alaska earthquake was reported to measure IX on the Modified Mercalli scale, which is equivalent to 8.5 on the Richter scale. It occurred on March 27, 1964, at 5:36 p.m., and its epicenter was located about 68 miles east of Anchorage. Its duration was estimated at 2.5 to 5 minutes (Stephenson, 1964). The earthquake caused a loss of 115 lives and over $300 million in damage in Alaska (Federal Reconstruction and Development Planning Commission for Alaska, 1964).

The earthquake was not an unusual occurrence in the area. About 7 percent of the seismic energy released each year worldwide originates in southern Alaska and the adjoining Aleutian Island chain (Gutenberg and Richter, 1949). In this century alone, there were eight Alaskan earthquakes that have equaled or exceeded magnitude 8 on the Richter scale. A total of 56 events have had magnitudes between 7 and 8, and 234 have had magnitudes between 6 and 7 (Wood, 1966). The 1964 earthquake was characterized by all the seismic effects that a major earthquake is capable of inflicting. Three principal sources of damages experienced during the earthquake included (1) tectonic subsidence and uplift altering Alaska shorelines, (2) seismic action with ground shaking felt over an area of 700,000 square miles and causing crucial deformation over an area larger than 100,000 square miles, and (3) destructive forces caused or triggered by seismic action such as tsunami, seiches, and slide-induced waves, resulting in loss of life and damages in coastal communities (Committee on the Alaska Earthquake, 1973).

General Effects of the Earthquake

The developed areas stricken by the earthquake (mainly Anchorage, Kodiak, Seward, and Valdez) contained almost one-half of the state's population and formed the major economic base of the state. The major structural damage was caused primarily by ground failure and tsunamis, with a limited damage resulting from ground shaking. According to the survey conducted by the Alaska State Housing Authority, there were 2,358 private properties with damage over $1,000 with total damages of more than $62 million. Much greater damages were incurred by public property; these were in excess of $234 million. Many buildings in Anchorage collapsed, including a multistory apartment building. The downtown area of Kodiak was inundated by the major tsunami, and at Valdez, Seward, and Whittier, oil storage tanks were ruptured and burned. Extensive damage was inflicted to surface transportation facilities including port facilities, docks, and bridges. The loss of land and sea transport facilities crippled Alaska's economy.

DAMAGE TO WATER SYSTEMS

Anchorage Area

Water Supply and Distribution System

At the time of the earthquake, the city of Anchorage Water Utility supplied about 8 million gallons of water per day, half from a federally owned dam and intake structure on Ship Creek and half from seven wells located throughout the city (Richardson, 1973). The Ship Creek water initially flowed through a 30-inch diameter cast-iron pipe to a valve pit, where the flow was divided to supply Anchorage, Fort Richardson, and Elmendorf Air Force Base. A 20-inch diameter welded steel pipeline delivered raw water to the city's treatment plant building where it was treated by coagulation/sedimentation and filtration processes. The plant was designed for gravity flow with electrically operated valves and a standby generator with a diesel engine.

From the treatment plant, water flowed to another valve and distribution box located 14,000 feet west through a 24-inch diameter wood-stave pipeline with no valves or taps. Another 16,000-foot section of the wood-stave pipeline delivered water to the distribution system. Its diameter was decreasing between valve boxes and distribution feeders.

The distribution system was comprised of 140 miles of line with diameters decreasing from 20 to 2 inches. All lines, about equally divided between cast iron and asbestos cement, were buried a minimum of 10 feet.

Earthquake Damages

The damage suffered by the Anchorage water supply system was related to the type of shock waves traveling through the soil. The Bootlegger Cove clay and silt underlying Anchorage has very poor shear strength and easily formed large landslides in response to the quake. All pipes in the landslide areas were almost completely destroyed. The main transmission lines and distribution pipes located in nonslide areas suffered numerous breaks. As a result, the water distribution system was completely drained shortly after the earthquake. However, about 80 percent of the system remained intact.

The treatment plant and deep-well pumps shut down immediately after the earthquake due to the failure of the electrical system in Anchorage. The plant suffered an extensive damage to a shear wall and minor damage to beams, columns, and floor slabs, therefore not losing its capacity to function. The plant's seismic design was in accordance with the 1958 edition of the Uniform Building Code.

Water supply sources were also affected by the earthquake. The flow of Ship Creek was temporarily reduced due to cracks and fissures in the earth. Domestic water supply at Fort Richardson and Elmendorf AFB was threatened by the lack of flow in Ship Creek. No major damages to the water purification plant or the distribution system on the posts were reported. One city well was lost and the other three were partially damaged.

Emergency Response and Restoration

Initial Response

Immediately after the earthquake, the water treatment plant was briefly inspected and declared usable. The emergency generator was started, and the plant resumed operation about one hour after the earthquake.

Water utility employees surveyed the distribution system using trucks with CB radios. Apparent breaks, slide areas, and grabens were immediately communicated to the central office. Subsequently, appropriate valves on the distribution system were closed in order to fill its usable portions and to prevent infiltration of groundwater or sewage. Some damaged portions of the system were made to exfiltrate water in order to prevent freezing.

City wells were inspected and four out of seven wells were put back in operation as soon as electric power was restored. Two wells were completely destroyed, and the pump house and the upper portion of well casings were damaged in the third well.

Temporary Water Service

The initial restoration of water supply by the utility could not assure sufficient quantities of potable water that were required immediately after the earthquake. Some facilities and disaster provisions that were maintained by the National Guard and the civil defense were not sufficient. In order to enable people to obtain water for drinking and cooking purposes, the military from Fort Richardson and Elmendorf AFB supplied truckloads of water in hardboard drums with sterile plastic liners and covers. The *ad hoc* disaster coordinators directed the military trucks to various points in the city. This emergency water supply service continued for as long as two weeks after the earthquake.

In one area of the city (located west of Fish Creek and north of Northern Lights Boulevard), the cement asbestos lines were badly fractured, and the area had to be entirely cut off from the distribution system. In order to supply water to this area, 60,000 feet of 4-inch diameter aluminum irrigation pipe and fittings were brought by Military Air Transport Service from the Seattle-Tacoma area to Elmendorf AFB for surface transportation to Anchorage.

The aluminum pipes were laid on top of the ground and connected to individual residences with 1/2-inch diameter garden hoses fastened to the outside faucet of the house. Aluminum lines were to be fed from fire hydrants located on the repaired and pressurized portions of the underground system through short lengths of fire hose. Contractors laid over 14 miles of temporary surface lines with the first line put in service on the fifth day after the earthquake. Water delivered through these temporary service lines had to be boiled before drinking and cooking by the request of the utility. All city water was declared drinkable on April 6, 1964, which was ten days after the earthquake.

Final Restoration of the System

Exact damages to the water system, including sources and distribution system, could not be assessed immediately after the earthquake due to climatic conditions. Some lines bled off as frost melted from the ground and new leaks showed up.

The final restoration of wells involved construction of a new pumphouse and restoration of the upper 20 feet of casing on Well Number 1. The well was redeveloped and tested by a contractor and put back in service. Another well was drilled to replace the two wells that were completely destroyed. The first site ended in a dry hole, but the second site was successfully drilled and allowed development of a complete facility yielding 1,080 gallons per minute of water with on-site fluoridation and chlorination.

The entire distribution system was studied to develop the scope of work on plans and specifications to be used in competitive-bid restoration contracts. To ensure that the restored system could stand subsequent inspection, the whole system was pressure tested by closing lines section by section. Asbestos cement lines were pressure tested for leaks at 150 psi, following with a 60 psi test for joint leaks. Lines were flushed and chlorinated with heavy doses of disinfectant. The unpleasant residual taste and odor after chorination led to less chlorine used in the subsequent restoration.

Service lines and in-house water systems of residences connected to the temporary surface lines were tested at a 50 psi gage pressure from a pump attached to the outside faucet. Leaks found inside the house were pointed out to the occupant. In the 415 homes tested, 40 breaks were found at street valves. It was suspected that the water main may have settled further than the house service line during the earthquake shaking which caused the sand bedding around mains and house services to compact and settle.

Seward Area

Water Supply System

The sources of water for Seward included two surface water intakes from Mt. Marathon and Jop Creek and three wells for supplemental supply and fire protection. Also, a saltwater fire protection system was extended from the dock into the downtown business area, and a 14-inch cast iron line delivered water from Forest Acres wells to a water storage tank in the downtown area. At the time of the earthquake, water supply was coming from Jop Creek and was supplemented by wells in Forest Acres operated through electrical remote water-level controls.

Earthquake Damages

The earthquake severely impacted the water system. Waterlines at numerous locations were broken due to the lateral movement, differential settlement, and fissures in the frozen ground. The flow from Jop Creek was diminished due to blocked intake and breaks in the supply line. The saltwater fire protection system was damaged since the dock slid into the bay together with pumps and intake. Further damages were inflicted by tsunamis. There was not enough water for fire fighting; therefore, no fire-fighting equipment was operational and fires in Seward burned uncontrolled.

Initial Response

Immediately after the earthquake, the Corps of Engineers together with the utility personnel inspected the Jop Creek water supply line and intake. Several line breaks were located and their temporary repair was undertaken. Intake flow was increased by shifting around chunks of ice.

The three wells were put into operation by installing portable generators obtained from Fort Richardson. However, due to line breaks, water from wells could not be delivered to other areas, and only nearby residents benefited from this emergency source.

A 4-inch diameter aluminum pipeline was brought by air from Anchorage, and a temporary surface delivery system was installed to provide water surface to areas with damaged underground systems.

Final Restoration

As had happened in Anchorage, all the earthquake damage to the water system was not evident at the time of the initial damage survey. Two wells in Forest Acres had to be rehabilitated, and one well was abandoned although the pump and controls were salvaged and used to install a new well. Pressure and leakage tests were made on buried lines. Necessary waterline repairs were made, and temporary above-ground service pipe was gradually removed as restoration continued. Water requirements of both the surviving and to-be-reconstructed facilities in Seward were studied by an engineer-architect in order to upgrade the entire distribution system to be able to serve all facilities when restored.

EMERGENCY PLANNING ENVIRONMENT

Emergency Preparedness Prior to the Event

At the time of the earthquake a very low level of disaster preparedness existed in the area. One reason for this was the relatively recent settlement of the area. Anchorage, a key Alaskan city, has been in existence for only 50 years. Having received statehood in 1959, Alaska had not yet assumed its full responsibilities as a state. The institutional framework within which disaster preparedness and response capabilities are developed and maintained was not fully formed; existing institutions lacked formal coordination. Secondly, there was little awareness of the seismic hazard even though the coastal area as far north as Fairbanks and the Aleutian Islands constitutes one of the world's most active zones. Four earthquakes (1912, 1928, and two in 1934) of magnitudes greater than 7.0 had occurred near the epicenter of the 1964 earthquake (Wood, 1966), but urban development and population inflows were just beginning. The new population, composed largely of immigrants and transients, may not have recognized the seismic threat. Finally, the evaluation of regions in terms of natural hazard vulnerability was not widely practiced. Existing disaster plans originated from civil defense programs and focused primarily on the threat of nuclear attack.

In the boroughs surrounding the Anchorage area, only the relatively small, incorporated city of Anchorage possessed an emergency preparedness institution. A city civil defense office served the incorporated area, and a state civil defense office was located in Anchorage. However, the city civil defense office was inoperative at the time of the earthquake; the director retired two weeks prior to the disaster, closing the office until his position could be filled. The state civil defense office was not well prepared to confront a major disaster. The Alaskan legislature had declined to fund the agency for the fiscal year 1965, and the agency was scheduled to dissolve on June 30, 1964--only three months from the date of the disaster (Cervantes, 1986). During the final months of phasing out all services, civil defense resources could not have represented an effective level of preparedness and emergency response capability. The Department of Public Works, responsible for essential services within the area, did not have an emergency operations plan. The military installations were the only area organizations who maintained established contingency procedures and response capabilities. The relationships between the public works superintendent and virtually all municipal and state organizations were highly personalized, consisting primarily of informal liaisons. Such interorganizational friendships do help to promote mutual aid agreements (Adams, 1969). However, they may be less reliable in the event of an extensive disaster where many resources or systems are threatened. In such cases a formal, preestablished aid agreement may facilitate the coordination of emergency response.

Postevent Organizational Response

Anchorage Public Works Organization

Adams (1969) provides a substantial account of the Public Works Department's organizational response to the crisis. The sections of the department that were normally responsible for the maintenance of public systems were prepared for disaster to some extent through their experience with routine operational emergencies such as distribution line breaks, power outages, and disruptions in water treatment activities. Construction, maintenance, and sanitation personnel faced basically the same tasks and priorities as in normal operations but were required to perform at a much greater speed and to do so in a disrupted environment. The scope of the disaster was too great for existing construction and maintenance personnel, and an additional work force was required. An extension of authority was necessary; public works employees frequently had to assume the responsibility of supervising emergency workers or pursuing their own efforts without direction. Many emergency reassignments were made at supervisory levels among maintenance personnel.

Engineering personnel were completely disrupted; their normal tasks were inapplicable to disaster conditions. Some assumed new tasks in the disaster response effort, while others remained relatively inactive until normal duties resumed. The survey and design sections of the engineering division were affected indirectly by the earthquake in terms of altered activity levels and design considerations during the repair and restoration period. Of the engineering personnel who assumed new tasks during the emergency, some experienced difficulties when their normal authority positions were reversed.

Customer services personnel faced the greatest upheaval, being totally unprepared for emergency response and the new tasks they had to assume after the earthquake. Many were placed at random into unfamiliar roles. Most activities of office personnel were suspended altogether. Those that remained had to adapt to the crisis environment, e.g., attempting to record hours worked by an expanded, emergency work force and to issue pay to new, undocumented workers. Public works administrators replaced normal activities with efforts to oversee repair and restoration operations and with new responsibilities such as agency liaison duties and the procurement of response materials.

Local Organizations

Both local and external organizations played major roles in the disaster response. The first interagency coordination meeting occurred less than ten hours after the earthquake and was attended by municipal officials, public health personnel, public utility executives, civil defense personnel, military officials, representatives of state and federal agencies, the Red Cross, and the Salvation Army. The Red Cross and Salvation Army organizations immediately implemented disaster response plans with trained personnel to provide essential relief and critical-care activities. Several local umbrella organizations were established specifically to meet postdisaster needs but were not maintained beyond the crisis due to their *ad hoc* nature (Selkregg et al., 1984).

State and Federal Organizations

Extensive support at the state level was marshaled for the relief and recovery effort. The dormant state civil defense organization was immediately reorganized and expanded, largely through volunteers, and served as the focal point for emergency operations. Civil defense officials assisted the military in the provision and distribution of emergency water supplies. National Guard troops were deployed to the damaged area within a few hours of the event.

The majority of relief activities was provided through federal resources. The military assumed a dominant role in response and restoration efforts by providing manpower, supplies, tools and equipment, and emergency housing, food, and water supplies. The U.S. Army Corps of Engineers performed debris clearance operations and emergency restoration of public roads, utilities, docks, schools, and hospitals (Selkregg et al., 1984). Less than a week after the earthquake, the Federal Reconstruction and Development Planning Commission for Alaska (Federal Reconstruction Commission, or FRC) was established by Executive Order 1150 to coordinate relief and reconstruction activities of the various federal agencies in Alaska. The FRC contained the following nine task forces:

(1) Community facilities
(2) Economic stabilization
(3) Financial institutions
(4) Housing
(5) Industrial development
(6) Natural resources development
(7) Ports and fishing
(8) Transportation
(9) Scientific and engineering

The commission and staff operated in Washington, D.C., and coordinated activities on the scene via a field committee composed of representatives of the Alaskan offices of various federal agencies. Alaska's Governor Egan established the Alaska Reconstruction and

Development Planning Commission to provide formal state participation in the activities of the FRC. Special legislation arising from the efforts of the FRC included the granting of transitional funds, in addition to the original transitional grant authorized at the establishment of statehood to help the state assume public services previously provided by the federal government. Amendments to the Alaska Omnibus Act authorized additional federal disaster assistance which included sizable support for urban renewal projects. This provided the opportunity to replan substantial areas in several communities for safer and more functional uses. The relocation of the entire town of Valdez was accomplished through urban renewal powers. Six months after the earthquake, the NRC was officially dissolved. Although reconstruction was well underway, the elimination of the commission so soon after the disaster reduced the adoption of many of its recommendations and removed a much-needed mechanism for the long-term monitoring of actions involving high-risk areas (Mader et al., 1980).

PRESENT STATUS OF EMERGENCY WATER PLANNING

Natural Hazards in Alaska

Natural hazards in Alaska encompass far more than the threat of earthquakes. The Yukon and other Interior regions are consistently exposed to flooding during the spring breakup of ice and snow from the higher elevations. Although the Interior is not well populated, communities must protect their water supply and wastewater systems from inundation and contamination. Extreme temperatures and the presence of permafrost in the northern and central areas present particular challenges to water systems. The coastal areas are the most hazardous environments, as well as the most heavily populated. Winter storms with high tides and strong winds threaten communities from Bristol Bay to Nome. The seismic threat is ever present along the southern coast, as is that of deadly, damaging tsunami.

Institutional Framework

There is a great need in Alaska for the development of an institutional framework to support hazard mitigation and prevention activities. Over the past twenty years, the areas ravaged by the great Alaska earthquake have seemed to achieve a steady improvement in emergency planning and preparedness. The evolution has fluctuated over time as economic and political forces varied.

Local

A greater awareness of the necessity of initiating emergency planning and preparedness activities was created, and many communities immediately initiated a planning process where none had existed previously. After the disaster, area utilities started to conceptualize their systems within the context of seismic threat, and seismic design adaptations soon began to be incorporated into Alaskan water system engineering. In some instances water utilities refused to extend service to areas of extreme seismic vulnerability where development proceeded regardless of high-risk designation.

Municipalities began instituting emergency planning programs soon after the disaster. Anchorage's first emergency plan began as a civil defense document specific to nuclear attack hazard and was revitalized and gradually modified after the earthquake to address a broader range of hazards. The borough of Kodiak developed an emergency preparedness plan in 1973 although the plan has not been effectively updated and maintained. The city of Valdez maintains an emergency preparedness plan and conducts annual earthquake drills in city schools (Selkregg et al., 1984). Seward developed a general emergency response plan in the late 1960s.

Municipal land use planning agencies and regulations are an important institutional component of emergency planning. There is not, nor has there ever been, political support for restrictive controls. Many of the seismically vulnerable areas in Anchorage are prime sites located in the downtown business and residential sections. The rapid development fueled by federal reconstruction activities and sustained by the installation of the Trans-Alaska Pipeline has steadily increased land values particularly in the desirable yet vulnerable prime areas of Anchorage. Dating from the first days of reconstruction, political and economic aspects within the growing city have consistently outweighed seismic hazard aspects, although stricter design requirements have appeared in an effort to reduce vulnerability and forestall stricter land use regulations. Due to the extent of the redevelopment of vulnerable areas, it is estimated that structural damage to water systems during future earthquakes may equal or exceed that of 1964.

The continual interchange between prodevelopment interests and the small but active community of hazard mitigation proponents has resulted in periodic movements toward mitigation and preparedness. In 1976, the Geotechnical Advisory Commission was established to act in an advisory capacity to the municipal assembly, the mayor, and municipal heads and commissions to provide geological and technical expertise. The commission has no regulatory or enforcing powers.

Ironically, the very economic development that has fueled land use controversy has also allowed the municipality to create and maintain excellent emergency services facilities. Both the fire and police departments enjoy large, modern systems with extensive response capabilities. The Office of Emergency Management, a division of the Fire Department, is active in emergency preparedness and maintains a well-developed Municipal Emergency Operations Plan. A long history of emergency response coordination between the municipality and area military establishments includes conducting regular emergency response exercises. This dynamic emergency preparedness environment sharply contrasts that of March, 1964.

State and Federal

The state began to take a more active role in determining the hazardousness of regions and in encouraging mitigation measures and appropriate land use planning. The Disaster Relief Act of 1974 and the Alaska Disaster Act of 1978 assigned responsibility for emergency preparedness and response to the Division of Emergency Services. A state emergency response plan was adopted in 1978.

During the 1970s federal acknowledgment of the importance of structured emergency management steadily increased. The Disaster Act of 1970, the Disaster Relief Act of 1974, and the Earthquake Hazards Reduction Act of 1977 were followed by the establishment in 1979 of the Federal Emergency Management Agency. The U.S. Environmental Protection Agency is also mandated to participate in the planning and provision of emergency water supply capabilities. In the event of contamination of normal supply sources, the U.S. Army Corps of Engineers has the responsibility of providing emergency water supplies.

Emergency Planning

Utility Plans

In 1982, the Anchorage Water and Wastewater Utility (AWWU) developed a Disaster Response Plan. The goal of the plan is "to serve as a reference for effective and efficient resource allocation through pre-planning, coordination with community resources and the assignment of utility manpower and equipment during the first 72 hours after an emergency situation exists. . . . during a disaster, the Municipal Water & Wastewater Utility will dedicate the maximum effort of its resources for as long as necessary toward the full restoration of utility services to a safe and sanitary level" (AWWU, 1986). The plan manual is to be reviewed and updated annually. In addition to goals and objectives, the introductory section includes (1) an executive call-out list; (2) a list of operational priorities which are not ranked or weighted in order to permit the restructuring of priorities according to the time and nature of a disaster; and (3) information on the AWWU Disaster Advisory Committee, including names, positions of employment, assigned responsibilities, and a ranked listing of alternative response sites for committee members. The purpose of the Disaster Advisory Committee is to offer administrative support throughout the emergency period.

The plan itself offers response instructions for all utility personnel. Each potential response activity is listed along with specific authorization(s), respondents, responsibilities, and appropriate actions. Disaster organization teams are prearranged for immediate organization in an emergency. Eleven teams are listed and assignments given for team captains, members, and duties. Separate sections outline alternative channels of communications and emergency response logistics such as food, water, and overnight accommodations for utility personnel. The final sections provide an index of disaster response resources, such as local unions, suppliers, contractors, equipment inventories from primary contractors, AWWU equipment inventories, and utility fuel requirement specifications. The utility always stocks a 30-day supply of necessary materials, including chemicals, and requires all suppliers to do the same so that a 60-day supply stock is available in the event of disrupted deliveries. The utility owns a standard Army Erdlator water purification unit and has equipped a first aid van. The AWWU also maintains a Strike Plan to ensure the continuation of services in the event of a work stoppage.

Municipal Plans

The municipality of Anchorage has developed a comprehensive emergency operations plan. The Fire Department provides fire, rescue, emergency medical, and emergency management services. Within the Fire Department, the maintenance and revision of the municipal plan is the responsibility of the Office of Emergency Management. Past versions of the plan have included an earthquake-specific component consisting of two parts: earthquake mitigation and postearthquake response. Under the municipal plan, the water and sewer utility's response duties include the coordination of water and sewer utility damage assessments; the repair and restoration of water and sewer services, in coordination with the fire and health departments; the coordination of outside and military assistance to the water and sewer utility; the provision of emergency water and sanitary facilities; and the disinfection of sewage spills. The most recent revision aligns the plan with FEMA's Integrated Emergency Management System.

State Plans

The state plan assigns responsibility for the monitoring and technical supervision of existing and emergency water supplies and the assessment of postdisaster community water needs to the Department of Environmental Conservation (DEC). The deputy commissioner of the DEC is the director of the Emergency Water Agency, and his/her duties include directing the redistribution of water supply equipment to correct deficiencies and coordinating efforts with federal agencies for primary water supplies where applicable. The Division of Emergency Services is responsible for coordinating all emergency relief actions, and the National Guard is responsible for conducting state military support operations to civil authority.

Water System Engineering for Hazardous Environments

General

The Anchorage area utility is currently building a 35 mgd water treatment plant with an expansion capacity of 70 mgd that has been designed for a worst-case seismic event. The 10 mgd Ship Creek treatment facility recently has been expanded to 24 mgd with the expansion constructed in accordance with current seismic design standards. The utility has used seismically resistant ductile-iron pipe almost exclusively for the past decade, although the initial decision to use ductile iron was generated from its overall desirability rather than from specific considerations of seismic design.

Utilities in southeastern Alaska must include seismic design considerations but face milder temperatures and usually bury pipelines at a depth of three feet. In Anchorage, pipeline depths range from 10-15 feet with pumps in systems and services to provide constant circulation in order to prevent freezing. This method results in extremely high pumping costs as well as increasing vulnerability if power supplies are disrupted. In the north lifelines must be encased within protective, insulated, heated structures called utilidors; if these structures were to be rendered inoperable due to a natural or manmade incident, severe losses might result.

AWWU Emergency Water Supply System

Currently, half of Anchorage's water supply consists of surface water from Ship Creek with the remainder obtained from deep wells located throughout the area. The AWWU system is completely computerized and monitors its water supply via a computer-generated peak demand chart. The chart reveals the total system storage capacity for the past 24-hour period, the current total possible production, and the estimated actual production, as well as peak demand estimates for the next four hours. The peak four-hour demand estimate equals estimated actual production plus calculated reservoir drop and provides information on the supply actually available for the upcoming four-hour period.

In monitoring these levels, certain response zones are prearranged in order of increasing severity. If a shortage is indicated, the estimated turnaround time in restoring lowered supply capability is calculated. If the turnaround time is insufficient to meet projected demand, a utility alert occurs. If the shortage continues into the next period of demand and the assurance of adequate fire protection supplies is threatened, the utility issues a public alert in which the severity of the impending shortage necessitates alerting the public through the media and conducting field checks of emergency conditions. A field crew is retained on active status to reduce emergency response time. In the final and most serious stage, the entire system is switched to manual control to provide strict allocation of available supplies. Low-priority uses are actually shut off so that only critical demands on the system remain. Automatic and telemetered functions are periodically switched to manual operations to assure that personnel remain prepared to assume control of the system.

Eklutna Project

The Eklutna Project of the AWWU entails the construction of a 30-mile pipeline to bring water from Eklutna Lake to the city of Anchorage. By the year 2025, the pipeline will have the capacity to supply 75 percent of the area's water needs. At the lake, water will pass from the intake into a .75 megawatt energy recovery station, then to a 35 mgd water treatment plant, and finally into a 15-mil gal clear well. Water will be transported from the clear well to the Ship Creek diversion point in Anchorage where it will be mixed with Ship Creek supply and distributed. The pipeline crosses two active faults and several that are believed to be inactive.

In designing the pipeline, three types of cylinders were considered--reinforced concrete, steel mortar-coated, and ductile iron--any of which would satisfy seismic design requirements. The lowest-bidding contract utilized AMORON concrete cyclinders with welded steel pipe. The pipeline consists of four sections of 54-inch pipe. At the Anchorage end, ten turnout vaults have been included to allow future expansion of the the distribution system. The pipeline will be buried at depths of 5-15 feet and fully insulated with overfilling wherever full depths are unattainable. This design should prevent freezing through the conditions of a 100-year-low temperature. Seismic design considerations include the use of shorter bell-and-spigot joints for increased flexibility. Additionally, all AWWU inspectors and contractors have been trained to identify potential fault lines.

The system has been designed to include sufficient storage by the year 2025 to meet basic water needs through a four-day disruption of pipeline service. To expedite response in the event of damage to the pipeline, the project specifications include the acquisition of large stockpiles of pipeline, tools, and materials. Sections identified as being particularly vulnerable to disruption, such as fault line and stream crossings, often require adaptive design practices; particular emphasis has been placed on stockpiling pipe for such sites.

Summary and Conclusions

Lessons Learned

Emergency water supply and system restoration experiences following the Alaska earthquake illustrate key lessons in emergency planning and response. The first is the necessity of conducting a thorough hazards vulnerability analysis of utility locations to identify potential threats. This knowledge is essential to the determination of appropriate mitigation and preparedness measures. A second is the desirability of collecting and maintaining stores of materials that would be suitable for implementing emergency repair and distribution activities in a given area. For example, the feasibility of alternative emergency distribution systems might vary from one system to another according to climate, service density, and supply source. Maintaining stores of supplies and materials appropriate to the optimum distribution scheme would facilitate rapid implementation.

A third lesson that is clearly illuminated is the importance of maintaining auxiliary water supply sources. The presence of usable emergency supplies can reduce the problems of postdisaster potable water provision to those of distribution and system restoration. Reducing emergency source uncertainties could increase reliability, decrease equipment and personnel requirements, and decrease response implementation time.

Fourthly, the Alaska experience serves as an example of the logistical difficulties of establishing emergency water services. If the affected area or population is large, or if damages are severe, the extensive equipment, materials, and personnel requirements of emergency water provision may exceed local resources, necessitating assistance from state or federal entities. In most areas, the organizations possessing such resources are military groups such as state National Guard or federal armed forces installations.

Finally, the organizational responses within the Anchorage Public Works Department present important implications for emergency water planning. Procedures to facilitate rapid system repair under adverse conditions, e.g., the stockpiling of pipes, tools, and materials, would benefit maintenance crews in their efforts to stabilize a threatened or damaged system as quickly as possible. Emergency training and cross-training of utility personnel are vital to the efficient use of labor in a crisis situation, so that employees are neither stripped of useful action nor thrust into crisis management tasks for which they have neither skills nor preparation. Specific emergency task assignments should be made in advance to effectively utilize personnel resources and to avoid duplication or omission of tasks. Employees should be made aware of the possibility of authority shifts and other psychological or behavioral phenomena commonly manifested during emergencies in order to facilitate their ability to adapt to emergency environments. Vital organizational functions, such as the hiring of auxiliary personnel, supplies procurement, and the maintenance of payroll calculation and distribution capabilities, should be carefully considered so that procedures may be developed to sustain these functions during an emergency (Adams, 1969).

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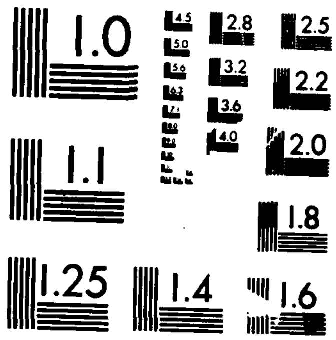
APPENDIX C:

LIST OF SUPPLIERS

AD-A183 091 EMERGENCY WATER PLANNING FOR NATURAL AND MAN-MADE 4/4
EMERGENCIES: AN ANALYTI..(U) PLANNING AND MANAGEMENT
CONSULTANTS LTD CARBONDALE IL J F LANGOWSKI ET AL.
UNCLASSIFIED APR 87 IWR-87-R-6 DACW72-84-C-0004 F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE C-1

SUPPLIERS OF ANALYTICAL DEVICES

Product	Supplier Name
Air Toxicity Monitors	Capital Controls Co. Inc. Harco Corp. Heath Consultants Inc.
Analytical Measuring Devices	Capital Controls Co. Inc. Fischer & Porter Co., Environmental Div. Foxboro Municipal Sales Div., The Foxboro Company Hach Co. Integrated Efficiency Systems Inc. Klett Manufacturing Co. Inc. Perkin-Elmer Co. Wallace & Tiernan, Div. Pennwalt Corp. Western Chemical Co.
Analytical Testing Services	Brown & Caldwell Laboratories Montgomery Laboratories National Sanitation Foundation Orlando Laboratories Inc. P. E. LaMoreaux & Associates Princeton Testing Laboratory Inc. Roy F. Weston Inc. Wilson Laboratories
Chlorine Residual Measuring Devices	Capital Controls Co. Inc. Chemply, Div. of United Chemicals Inc. Fischer & Porter Co., Environmental Div. Hach Co. Miles ETS Wallace & Tiernan, Div. Pennwalt Corp.
Field Test Kits	Hach Co. Hersey Products Inc. Technical Products Corp.

TABLE C-1 (Continued)

Product	Supplier Name
Manometers	Badger Meter Inc. BIF, Unit of General Signal Corp. Wallace & Tiernan, Div. Pennwalt Corp.
Nephelometers	Advanced Polymer Systems Inc. Capital Controls Co. Inc. Hach Co. Roberts Filter Manufacturing Co. Western Chemical Co.
Water Level Indicators	Fischer & Porter Co., Environmental Div. Fisher Research Lab. Johnson Screens Inc. McCrometer, Div. of Ametek Inc. Joseph G. Pollard Co. Inc.

Source: American Water Works Association 1986 Buyers' Guide.

TABLE C-2

SUPPLIERS OF CHEMICALS

Product	Supplier Name
Activated Carbon	Chemply, Div. of United Chemicals Inc.
	Culligan USA
	Hankin Environmental Systems Inc.
	Hungerford & Terry Inc.
	Husky Industries Inc., Industrial Div.
	Roberts Filter Mfg. Co.
	Southern Products & Silica Co. Inc.
	Tonka Equipment Co.
	Unifilt Corp.
Caustic Soda	Chemply, Div. Of United Chemicals Inc.
	Chemtech Industries Inc., Manufacturing Products Div.
	Olin Corp., Chemicals Group
Chlorine	Chemply, Div. Of United Chemicals Inc.
	Olin Corp., Chemicals Group
	Rio Linda Chemical Co. Inc.
	Wallace & Tiernan, Div. Pennwalt Corp.
Coagulants	Allied Chemical Co.
	Chemply, Div. of United Chemicals Inc.
	Nalco Chemical Co.
	QC Corp.
	Western Chemical Co.
Dechlorinating Agents	Allied Chemical Co.
	Capital Controls Co. Inc.
	Chemply, Div. of United Chemicals Inc.
Ferric Chloride	Chemply, Div. Of United Chemicals Inc.
	Western Chemical Co.
Iron and Manganese Removal Chemicals	Carus Chemical Co.
	Chemply, Div. of United Chemicals Inc.
	Culligan USA
	Emery Industries Div., NDCC
	Hungerford & Terry Inc.
	Nalco Chemical Co.
	Olin Corp., Chemicals Group
	Stiles-Kem, Div. of Met-Pro Corp.
	Technical Products Corp.
	Western Chemical Co.

TABLE C-2 (Continued)

Product	Supplier Name
Lime	Chemply, Div. of United Chemicals, Inc.
Potassium Permanganate	Carus Chemical Co. Chemply, Div. of United Chemicals, Inc.
Soda Ash	Allied Chemical Co. Chemply, Div. of United Chemicals, Inc.
Sulfur Dioxide	Chemply, Div. of United Chemicals, Inc. Technical Products Corp.
Sulfuric Acid	Allied Chemical Co. Olin Corp., Chemicals Group
Taste and Odor Removal Chemicals	Allied Chemical Co. Carus Chemical Co. Chemply, Div. of United Chemicals Inc. Culligan USA Emery Industries Inc., NDCC Husky Industries Inc., Industrial Div. Olin Corp., Chemicals Group

Source: American Water Works Association 1986 Buyer's Guide.

TABLE C-3

SUPPLIERS OF EQUIPMENT

Product	Supplier Name
Aerators	Clow Corp Hungerford & Terry Inc. Infilco Degremont Inc. Roberts Filter Mfg. Co. Tonka Equipment Co. Walker Process Corp.
Agitators	Dorr-Oliver Inc. Hungerford & Terry Inc. Roberts Filter Mfg. Co.
Chemicai Feed Apparatus	BIF, Unit of General Signal Corp. Capital Controls Co. Inc. Carlon Meter Co. Clow Corp. Culligan USA Fischer & Porter Co., Environmental Div. Industrial Filter & Pump Mfg. Co. Liquid Metronics Inc. Nalco Chemical Co. Wallace & Tiernan, Div. Pennwalt Corp. Western Chemical Co.
Chlorination Equipment	A/C Pipe Inc. BIF, Unit of General Signal Corp. Capital Controls Co. Inc. Culligan USA Fischer & Porter Co., Environmental Div. Wallace & Tiernan, Div. Pennwalt Corp.
Controllers, Motor and Electric	Autocon Industries Inc. Bristol Babcock Inc. Signet Scientific Co.

TABLE C-3 (Continued)

Product	Supplier Name
Controllers, Pressure	A/C Pipe Inc. Autocon Industries Inc. BIF, Unit of General Signal Corp. Bristol Babcock Inc. Cypro Inc. Fischer & Porter Co., Environmental Div. Foxboro Municipal Sales Div., The Foxboro Co. Mueller Co. Signet Scientific Co. Turbitrol Co.
Controllers, Rate of Flow	BIF, Unit of General Signal Corp. Bristol Babcock Inc. Fischer & Porter Co., Environmental Div. Foxboro Municipal Sales Div., The Foxboro Co. GA Industries Inc. F. B. Leopold Co. McCrometer, Div. of Ametek Inc. Rockwell Intl., Municipal & Utility Div. Signet Scientific Co. Turbitrol Co. Wallace & Tiernan, Div. Pennwalt Corp. Zurn Industries Inc., Hays Fluid Controls Div.
Drilling Machines, Pipe	A/C Pipe Inc. Apac Products Concord-Daigle Inc. Mueller Co. Pilot Mfg. Co. Joseph G. Pollard Co. Inc.
Earth Digging, Boring, Moving Equipment	Stanley Hydraulic Tools
Filter Plant Equipment	BIF, Unit of General Signal Corp. Culligan USA Hungerford & Terry Inc. Krofta Engrg. Corp. F. B. Leopold Co. Paterson Candy Intl. Ltd. Roberts Filter Mfg. Co.

TABLE C-3 (Continued)

Product	Supplier Name
Filter Plant Equipment (Cont.)	Tonka Equipment Co. Turbitrol Co. Walker Process Corp.
Insert Machines, Valve and Fitting	A/C Pipe Inc. Hydra-Stop Inc. Mueller Co. Pont-A Mousson S.A. Taisei Kiko Co. Ltd. U.S. Pipe & Foundry Co. Zurn Industries Inc., Hayes Fluid Controls Div.
Ion-Exchange Equipment	Culligan USA Hungerford & Terry Inc. Industrial Filter & Pump Mfg. Co. Infilco Degremont Inc. Tonka Equipment Co. Western Chemical Co.
Ion-Exchange Materials	Culligan USA Hungerford & Terry Inc. Nalco Chemical Co. Tonka Equipment Co. Western Chemical Co.
Leak Detection Equipment	A/C Pipe Inc. F. S. Brainard & Co. Capital Controls Co. Inc. Dallas Specialty & Mfg. Co. Fischer & Porter Co., Environmental Div. Fisher Research Lab. Fluid Conservation Systems Corp. Heath Consultants Inc. Metrotech Corp. Pilot Mfg. Co. Joseph G. Pollard Co., Inc. Wallace & Tiernan Div., Pennwalt Corp. Watts Regulator Co.
Lime Slakers and Feeders	BIF, Unit of General Signal Corp. Dorr-Oliver Inc. Wallace & Tiernan, Div. Pennwalt Corp.
Mixing Equipment	Dorr-Oliver Inc. Infilco Degremont Inc. Tonka Equipment Co. Walker Process Corp.

TABLE C-3 (Continued)

Product	Supplier Name
Motors, Electric	Hayward Tyler Inc.
Pipe Cleaning Tools and Equipment	A/C Pipe Inc. Girard Industries Inc. Heath Consultants Inc. Joseph G. Pollard Co. Inc. Polly Pig by Knapp Inc. Taisei Kiko Co. Ltd.
Pipe Cutting Machines	A/C Pipe Inc. ITT Grinnell Corp. Koch Fiberglass Products Pilot Mfg. Co. Joseph G. Pollard Co. Inc. Reed Mfg. Co. Stanley Hydraulic Tools E. H. Wachs Co.
Pumps, Air Lift	Johnson Screens Inc. Patterson Pump Co.
Pumps, Centrifugal	Aurora Pump, Unit of General Signal Corp. Byron Jackson Pump Div., Borg-Warner Dorr-Oliver Inc. Industrial Filter & Pump Mfg. Co. Johnson Pump Co. A. Y. McDonald Mfg. Co. Patterson Pump Co. Waterous Co. Worthington Pump Div., Dressor Industries Inc.
Pumps, Chemical Feed	Aurora Pump, Unit of General Signal Corp. BIF, Unit of General Signal Corp. Capital Controls Co. Inc. Culligan USA Dorr-Oliver Inc. Johnston Pump Co.
Pumps, Deep Well	Aurora Pump, Unit of General Signal Corp. Byron Jackson Pump Div. Borg-Warner Johnson Pump Co. Layne & Bowler Inc. A. Y. McDonald Mfg. Co.

TABLE C-3 (Continued)

Product	Supplier Name
Pumps, Deep Well (Cont.)	Western Land Roller Co.
	Worthington Pump Div., Dresser Industries Inc.
Pumps, Diaphragm	BIF, Unit of General Signal Corp.
	Capital Controls Co. Inc.
	Dorr-Oliver Inc.
	Liquid Metronic Inc.
	Joseph G. Pollard Co. Inc.
	Wallage & Tiernan, Div. Pennwalt Corp.
Pumps, Hydrant	A/C Pipe Inc.
	Joseph G. Pollard Co. Inc.
Pumps, Hydraulic Booster	Johnston Pump Co.
	Stanley Hydraulic Tools
	Worthington Pump Div., Dresser Industries Inc.
Pumps, Plunger Sludge	Dorr-Oliver Inc.
Pumps, Portable	A/C Pipe Inc.
	Joseph G. Pollard Co. Inc.
	Stanley Hydraulic Tools
	Waterous Co.
Pumps, Sewage	A/C Pipe Inc.
	Aurora Pump, Unit of General Signal Corp.
	Clow Corp.
	Dorr-Oliver Inc.
	A. Y. McDonald Mfg. Co.
	Patterson Pump Co.
	Stanley Hydraulic Tools
	Worthington Pump Div., Dresser Industries Inc.
Pumps, Submersible	A/C Pipe Inc.
	Aurora Pump, Unit of General Signal Corp.
	Byron Jackson Pump Div., Borg-Warner
	Clow Corp.
	Johnson Screens Inc.
	Johnston Pump Co.
	Layne & Bowler Inc.
	A. Y. McDonald Mfg. Co.
	Stanley Hydraulic Tools
	E. H. Wachs Co.

TABLE C-3 (Continued)

Product	Supplier Name
Pumps, Submersible (Cont.)	Worthington Pump Div., Dresser Industries Inc.
Pumps, Sump	A/C Pipe Inc.
	Aurora Pump, Unit of Signal Corp.
	Byron Jackson Pump Div., Borg-Warner
	Clow Corp.
	Layne & Bowler Inc.
	A. Y. McDonald Mfg. Co.
	Stanley Hydraulic Tools
	Worthington Pump Div., Dresser Industries Inc.
Pumps, Turbine	Aurora Pump, Unit of General Signal Corp.
	Byron Jackson Pump Div., Borg-Warner
	Johnston Pump Co.
	Layne & Bowler Inc.
	A. Y. McDonald Mfg. Co.
	Western Land Roller Co.
	Worthington Pump Div., Dresser Industries Inc.
Surface Wash Equipment	BIF, Unit of General Signal Corp.
	Hungerford & Terry Inc.
	F. B. Leopold Co.
	Roberts Filter Mfg. Co.
	Tonka Equipment Co.
	Turbitrol Co.
Water Testing Equipment	Advanced Polymer Systems, Inc.
	Capital Controls Co. Inc.
	Chemply, Div. of United Chemicals Inc.
	Culligan USA
	Dallas Specialty & Manufacturing Co.
	Hach Co.
	Miles ETS
	Nalco Chemical Co.
	Technical Products Corp.
	Wallace & Tiernan, Div. Pennwalt Corp.
Weir Equipment	BIF, Unit of General Signal Corp.
	Rodney Hunt Co., Water Control Equipment Div.
	F. B. Leopold Co.
	Joseph G. Pollard Co. Inc.
	Tonka Equipment Co.

Source: American Water Works Association 1986 Buyers' Guide.

TABLE C-4

SUPPLIERS OF SAFETY AND SECURITY COMPONENTS

Product	Supplier Name
Radio Equipment, Mobile	Amocams Inc.
Reservoir Covers	Burke Industries Carlisle Syntec Systems, Div. Carlisle Corp. Pittsburgh-Des Moines Corp. Temcor
Safety Devices and Equipment	Capital Controls Co. Inc. Fisher Research Lab. Heath Consultants Inc. Joseph G. Pollard Co. Inc.
Security Systems	Amocams Inc. Capital Controls Co. Inc.

Source: American Water Works Association 1986 Buyers' Guide.

TABLE C-5

SUPPLIERS OF SYSTEM REPAIR MATERIALS

Product	Supplier Name
Cement, Leak-Sealing	A/C Pipe Inc.
Clamps, Pipe Joint	A/C Pipe Inc. Clow Corp. Concord-Daigle Inc. Dresser Mfg. Div. Dresser Industries Ford Meter Box Co. Inc. ITT Grinnell Corp.
Clamps, Pipe Repair	A/C Pipe Inc. Apac Products Clow Corp. Columbus Standard Water Works Equipment Co. Concord-Daigle Inc. Dresser Mfg. Div. Dresser Industries Ford Meter Box Co. Inc. Gifford-Hill-American Inc. ITT Grinnell Corp. JCM Industries Inc. James Jones Co. Mueller Co. Joseph G. Pollard Co. Inc. Rockwell Intl. Municipal & Utility Div. Romac Industries Inc. Taisei Kiko Co. Ltd. Texas Foundries Inc.
Controllers, Motor & Electric	Autocon Industries Inc. Bristol Babcock Inc. Signet Scientific Co.
Controllers, Pressure	A/C Pipe Inc. Autocon Industries Inc. BIF, Unit of General Signal Corp. Bristol Babcock Inc. Cypro Inc. Fischer & Porter Co. Environmental Div. Foxboro Municipal Sales Div. The Foxboro Co. Mueller Co. Signet Scientific co. Turbitrol Co.

TABLE C-5 (Continued)

Product	Supplier Name
Controllers, Rate of Flow	BIF, Unit of General Signal Corp.
	Bristol Babcock Inc.
	Fischer & Porter Co. Environmental Div.
	Foxboro Municipal Sales Div. The Foxboro Co.
	GA Industries Inc.
	F. B. Leopold Co.
	McCrometer, Div. of Ametek Inc.
	Rockwell Intl. Municipal & Utility Div.
	Signet Scientific Co.
	Turbitrol Co.
	Wallace & Tiernan, Div. Pennwalt Corp.
	Zurn Industries Inc. Hays Fluid Control Div.
Couplings, Flexible	A/C Pipe Inc.
	Apac Products
	Columbus Standard Water Works Equipment Co.
	Dallas Specialty & Mfg. Co.
	Dresser Mfg. Div. Dresser Industries
	Ford Meter Box Co. Inc.
	ITT Grinnell Corp.
	JCM Industries Inc.
	Nappco Inc.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
	Rockwell Intl. Municipal & Utility Div.
	Romac Industries Inc.
	Texas Foundries Inc.
Cross-Connection Devices	A/C Pipe Inc.
	Ames Co. Inc.
	Apco/Valve & Primer Corp.
	Cla-Val Co. Div. of Griswold Industries
	Febco Sales
	GA Industries Inc.
	Hersey Products Inc.
	ITT Grinnell Corp.
	Kent Meters Inc.
	Mueller Co.
	Ocean Valves Inc.
	PGL Corp.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
	Watts Regulator Co.

TABLE C-5 (Continued)

Product	Supplier Name
Curb Boxes	A/C Pipe Inc. Ametek/Plymouth Products Div. Bibby-Ste. Croix Foundries Inc. Bingham & Taylor Corp. Brooks Products Inc. Christy Concrete Products Inc. Concord-Daigle Inc. Ford Meter Box Co. Inc. ITT Grinnell Corp. A. Y. McDonald Mfg. Co. Mueller Co. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. Quazite Corp. Russell Pipe & Foundry Co. Inc. Tyler Pipe
Curb & Corporation Stops	A/C Pipe Inc. Ford Meter Box Co. Inc. ITT Grinell Corp. James Jones Co. A. Y. McDonald Mfg. Co. Mueller Co. Joseph G. Pollard Co. Inc. Pont-A Mousson S. A. Zurn Industries Inc. Hays Fluid Controls Div.
Drives: Belt, Chain, Gears, Etc.	Stanley Hydraulic Tools
Gages, Pressure and Vacuum	F. S. Brainard & Co. Bristol Babcock Inc. Fischer & Porter Co. Environmental Div. Foxboro Municipal Sales Div. The Foxboro Co. Joseph G. Pollard Co. Inc.
Gaskets and Packing	A/C Pipe Inc. Buckhorn Rubber Products Clow Corp. Columbus Standard Water Works Equipment Co. Hydra-Shield Mfg. Inc. Reeves Rubber Div. Florocarbon Co.

TABLE C-5 (Continued)

Product	Supplier Name
Goosenecks	A/C Pipe Inc. James Jones Co. Joseph G. Pollard Co. Inc.
Hose Suction and Discharge	Goodall Rubber Co. Joseph G. Pollard Co. Inc.
Hydrants, Fire	A/C Pipe Inc. American Cast Iron Pipe Co. Clow Corp. Concord-Daigle Inc. East Jordan Iron Works Inc. Hydra-Shield Mfg. Inc. James Jones Co. Kennedy Valve, Div. of ITT Grinnell Valve Co. Inc. Long Beach Iron Works Inc. Mueller Co. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. US Pipe & Foundry Co. Waterous Co.
Inserting Services, Valve and Fitting	Hydra-Stop Inc. Pont-A Mousson S.A. Taisei Kiko Co. Ltd. US Pipe & Foundry Co. Zurn Industries Inc. Hays Fluid Controls Div.
Jointing Materials	A/C Pipe Inc. Bibby-Ste, Croix Foundries Inc. Columbus Standard Water Works Equipment Co. EBAA Iron Inc. L. B. Foster Co. ITT Grinnell Corp. Kendall Co. Magotteaux Canada SCC Reilly Tar & Chemical Corp. Rockwell Intl. Municipal & Utility Div.
Jointing Tools	A/C Pip Inc. ITT Grinnell Corp. JCM Industries Inc. Mueller Co.

TABLE C-5 (Continued)

Product	Supplier Name
Jointing Tools (Cont.)	Pilot Mfg. Co.
	Joseph G. Pollard Co. Inc.
	Taisei Kiko Co. Ltd.
	Tyler Pipe
Joints, Mechanical, Pipe	A/C Pipe Inc.
	American Cast Iron Pipe Co.
	Clow Corp.
	Columbus Standard Water Works Equipment Co.
	Dresser Mfg. Div. Dresser Industries
	EBAA Iron Inc.
	Harrington Corp.
	ITT Grinnell Corp.
	JCM Industries Inc.
	Koch Fiberglass Products
	Pont-A Mousson S.A.
	Rockwell Intl. Municipal & Utility Div.
	Russell Pipe & Foundry Co. Inc.
	Taisei Kiko Co. Ltd.
	Texas Foundries Inc.
	Tyler Pipe
	Vianini Pipe Inc.
Leak Detection Services	F. S. Brainard & Co.
	Fluid Conservation Systems Corp.
	Harco Corp.
	Heath Consultants Inc.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
Locators, Pipe and Valve Box	A/C Pipe Inc.
	Berntsen Inc.
	Fisher Research Lab
	Heath Consultants Inc.
	Metrotech Corp.
	Pilot Mfg. Co.
	Joseph G. Pollard Co. Inc.
	Polly Pig By Knapp Inc.
	Radiotection Corp.
	Schonstedt Instrument Co.
Pipe, Distribution, Asbestos-Cement	A/C Pipe Inc.
	A/C Pipe Producers Assn.
	Capco Pipe Co. Inc.
	Certain-Teed Corp. Pipe & Plastics Group
	ITT Grinnell Corp.

TABLE C-5 (Continued)

Product	Supplier Name
Pipe, Distribution, Asbestos-Cement (Cont.)	J-M Mfg. Co. Inc.
	Pont-A Mousson A.S.
	Trinity Valley Iron & Steel Co.
Pipe, Distribution, Cast-Iron	A/C Pipe Inc.
	Bibby-Ste, Croix Foundries Inc.
	ITT Grinnell Corp.
	Pont-A Mousson S.A.
	Trinty Valley Iron & Steel Co.
Pipe, Distribution, Concrete	A/C Pipe Inc.
	American Concrete Pressure Pipe Assn.
	Ameron
	Gifford-Hill American Inc.
	ITT Grinnell Corp.
	Pont-A Mousson S.A.
	Price Brothers Co.
	Vianini Pipe Inc.
Pipe, Distribution, Copper	A/C Pipe Inc.
	ITT Grinnell Corp.
Pipe, Distribution, Ductile-Iron	A/C Pipe Inc.
	Americana Cast Iron Pipe Co.
	Clow Corp.
	Griffin Pipe Products Co.
	ITT Grinnell Corp.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
Pipe, Distribution, Fiberglass-Reinforced Plastic	A/C Pipe Inc.
	Amalga Corp.
	Ameron Fiberglass Pipe Div.
	J-M Mfg. Co. Inc.
	Koch Fiberglass Products
	Joseph G. Pollard Co. Inc.
	Price Brothers Co.
Pipe, Distribution, Poly-butylene	A/C Pipe Inc.
	ITT Grinnell Corp.
Pipe, Distribution, Pole-thylene	A/C Pipe Inc.
	Goodall Rubber Co.
	Pont-A Mousson S.A.

TABLE C-5 (Continued)

Product	Supplier Name
Pipe, Distribution, PVC	A/C Pipe Inc. Capco Pipe Co. Inc. Certain-Teed Corp. Pipe & Plastics Group Clow Corp. ITT Grinnell Corp. J-M Mfg. Co. Ltd. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. Scepter Mfg. Co. Ltd. Trinity Valley Iron & Steel Co.
Pipe, Distribution, Steel	A/C Pipe Inc. Ameron Confab Industrial S.A. Jay Forni Inc. L. B. Foster Co. ITT Grinnell Corp. Pont-A Mousson S.A. Progressive Fabricators Inc.
Pipe, Distribution, Other	A/C Pipe Inc. J-M Mfg. Co. Inc.
Pipe, Service, Copper	A/C Pipe Inc.
Pipe, Service, Polybutylene	A/C Pipe Inc. Joseph G. Pollard Co. Inc.
Pipe, Servie, Polyethylene	A/C Pipe Inc. Goodall Rubber Co. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A.
Pipe, Service, PVC	A/C Pipe Inc. J-M Mfg. Co. Inc. Pont-A Mousson S.A.
Pipe, Service, Other	J-M Mfg. Co. Inc.
Pipe Tools	A/C Pipe Inc. Pilot Mfg. Co. Joseph G. Pollard Co. Inc. Pow-R Devices Inc. Reed Mfg. Co.

TABLE C-5 (Continued)

Product	Supplier Name
Saddles, Pipe	A/C Pipe Inc. American Cast Iron Pipe Co. APAC Products Clow Corp. Concord-Daigle Inc. Dresser Mfg. Div. Dresser Industries EBAA Iron Inc. Ford Meter Box Co. Inc. L. B. Foster Co. Hersey Products Inc. ITT Grinnell Corp. JCM Industries Inc.
Sleeves	A/C Pipe Inc. American Cast Iron Pipe Co. Clow Corp. Columbus Standard Water Works Equipment Co. Dresser Mfg. Div. Dresser Industries Griffin Pipe Products Co. ITT Grinnell Corp. Mueller Co. Pont-A Mousson S.A. Rockwell Intl. Municipal & Utility Div. Russell Pipe & Foundry Co. Inc. Taisei Kiko Co. Ltd. Tyler Pipe US Pipe & Foundry Co.
Sleeves and Valves, Tapping	A/C Pipe Inc. American Cast Iron Pipe Co. Clow Corp. Concord-Daigle Inc. East Jordan Iron Works Inc. Gifford-Hill-American Inc. ITT Grinnell Corp. JCM Industries Inc. Kennedy Valve, Div. of ITT Grinnell Valve Co. Inc. Mueller Co. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. Rockwell Intl. Municipal & Utility Div. Romac Industries Inc. Taisei Kiko Co. Ltd. Tyler Pipe US Pipe & Foundry Co. Waterous Co.

TABLE C-5 (Continued)

Product	Supplier Name
Tanks, Steel, Bolted	Confab Industrial S.A. Peabody Tec Tank A. O. Smith Harvestore Products Inc. Smith Industries Inc. Trico Industries Inc.
Tanks, Steel, Welded	Confag Industrial S.A. Culligan USA Fisher Tank Co. Peabody Tec Tank Pittsburg-Des Moines Corp.
Tank Erection	Fisher Tank Co. NA Con Services Inc. Pittsburg-Des Moines Corp.
Tank Inspection	NA Con Services Inc. Sterling Div. Reichhold Chemicals Inc. Watertower Paint & Repair Co. Inc.
Tank Painting	NA Con Services Inc. Sterling Div. Reichhold Chemicals Inc. Watertower Paint & Repair Co. Inc.
Tank Repair	Fisher Tank Co. NA Con Services Inc. Pittsburg-Des Moines Corp. Sterling Div. Reichhold Chemicals Inc. Watertower Paint & Repair Co. Inc.
Valve Actuators	A/C Pipe Inc. Amalga Corp. AMES Co. Inc. Auma Actuators Inc. Dezurik Dyna-Torque Inc. Flomatic Corp. Foxboro Municipal Sales Div. The Foxboro Co. Rodney Hunt Co. Water Control Equipment Div. ITT Grinnell Corp. Jenkins Canada Inc. Kennedy Valve, Div. of ITT Grinnell Valve Co. Inc. Keystone Valve-USA Mueller Co.

TABLE C-5 (Continued)

Product	Supplier Name
Valve Actuators (Cont.)	Pont-A Mousson S.A. Stanley Hydraulic Tools Stockham Valves & Fittings E. H. Wachs Co. Watts Regulator Co.
Valves, Air Relief	A/C Pipe Inc. AMES Co. Inc. APCO/Valve & Primer Corp. Bermad Irrigation Controls Cla-Val Co. Div. of Griswold Industries Clow Corp. Crispin Valve Div. Multiplex Mfg. Co. GA Industries Inc. ITT Grinnell Corp. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. Val-Matic Valves & Mfg. Corp.
Valves, Backflow Prevention	A/C Pipe Inc. AMES Co. Inc. APCO/Valve & Primer Corp. Cla-Val Co. Div. of Griswold Industries FEBCO Sales GA Industries Inc. Hersey Products Inc. ITT Grinnell Corp. Kent Meters Inc. Mueller Co. Ocean Valves Inc. PGL Corp. Joseph G. Pollard Co. Inc. Pont-A Mousson S.A. Watts Regulator Co.
Valves, Ball	A/C Pipe Inc. Dezurik Flomatic Corp. Ford Meter Box Co. Inc. GA Industries Inc. ITT Grinnell Corp. Jenkins Canada Inc. James Jones Co. McCrometer, Div. of Ametek Inc. A. Y. McDonald Mfg. Co. McNally Pittsburg Inc. Valve Div. PGI Corp. Pont-A Mousson S.A.

TABLE C-5 (Continued)

Product	Supplier Name
Valves, Ball (Cont.)	Henry Pratt Co.
	Stockham Valves & Fittings
	Watts Regulator Co.
	Western Chemical Co.
	Zurn Industries Inc. Hays Fluid Controls Div.
Valves, Butterfly	A/C Pipe Inc.
	American Cast Iron Pipe Co.
	APCO/Valve & Primer Corp.
	Clow Corp.
	Dezurik
	Flomatic Corp.
	ITT Grinnell Corp
	Jenkins Canada Inc.
	Kennedy Valve, Div. of ITT Grinnell Valve Co. Ind.
	Keystone Valve-USA
	F. B. Leopold Co.
	McNally Pittsburg Inc. Valve Div
	Mueller Co.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
	Henry Pratt Co.
	Stockham Valves & Fittings
	Texas Foundries Inc.
	US Pipe & Foundry Co.
	Waterman Industries Inc.
	Watts Regulator Co.
Valves, Check	A/C Pipe Inc.
	American Cast Iron Pipe Co.
	AMES Co. Inc.
	APCO/Valve & Primer Corp.
	Cla-Val Co. Div. of Griswold Industries
	Clow Crop.
	FEBCO Sales
	Flomatic Corp.
	Ford Meter Box Co. Inc.
	GA Industries Inc.
	Hersey Products Inc.
	Hydra-Shield Mfg. Inc.
	ITT Grinnell Corp.
	Jenkins Canada Inc.
	Kennedy Valve, Div. of ITT Grinnell Valve Co. Inc.
	Kent Meters Inc.
	Keystone Valve-USA

TABLE C-5 (Continued)

Product	Supplier Name
Valves, Check (Cont.)	F. B. Leopold Co.
	A. Y. McDonald Mfg. Co.
	Mueller Co.
	Muesco Inc.
	Ocean Valves Inc.
	PGL Corp.
	Joseph G. Pollard Co. Inc.
	Pont-A Mousson S.A.
	Stockham Valves & Fittings
	Val-Matic Valves & Mfg Corp.
	Wateman Industries Inc.
	Waterous Co.
	Watts Regulator Co.
	Western Chemical Co.
	Zurn Industries Inc. Hays Fluid Controls Div.
Valves, Compression	A/C Pipe Inc.
	Ford Meter Box Co. Inc.
	ITT Grinnell Corp.
	A. Y. McDonald Mfg. Co.
	NAPPCO Inc
	Zurn Industries Inc. Hays Fluid Controls Div.
Valves, Cone	Clow Corp.
	Dezurik
	McNally Pittsburg Inc. Valve Div.
Valves, Control	A/C Pipe Inc.
	AMES Co. Inc.
	APCO/Valve & Primer Corp.
	Bermad Irrigation Controls
	CLA-VAL Co. Div. of Griswold Industries
	FEBCO Sales
	Flomatic Corp.
	GA Industries Inc.
	ITT Grinnell Corp.
	Keystone Valves USA.
	Muesco Inc.
	Ocean Valves Inc.
	Henry Pratt Co.
	Watts Regulator Co.
	Western Chemical Co.
Valves, Electrically Operated	A/C Pipe Inc.
	American Cast Iron Pipe Co.
	AMES Co. Inc.

TABLE C-5 (Continued)

Product	Supplier Name
Valves, Electrically Operated (Cont.)	APCO/Valve & Primer Corp.
	Bermad Irrigation Controls
	Cla-Val Co., Div. of Griswold Industries
	Clow Corp.
	FEBCO Sales
	GA Industries Inc.
	ITT Grinnell Corp.
	Jenkins Canada Inc.
	Kennedy Valve, Div. of ITT Grinnell Valve Co. Inc.
	Keystone Valve-USA
	F. B. Leopold Co.
	McNally Pittsburg Inc. Valve Div.
	Mueller Co.
	Muesco Inc.
	Pont-A Mousson S.A.
	Henry Pratt Co.
	Stockham Valves & Fittings
	US Pipe & Foundry Co.
	Watts Regulator Co.
	Zurn Industries Inc. Hays Fluid Controls Div.
Valves, Pressure Regulating	A/C Pipe Inc.
	AMES Co. Inc.
	Bermad Irrigation Controls
	Cla-Val Co. Div. of Griswold Industries
	FEBCO Sales
	GA Industries Inc.
	ITT Grinnell Corp.
	Mueller Co.
	Muesco Inc.
	Joseph G. Pollard Co. Inc.
	Henry Pratt Co.
	Watts Regulator Co.
Valves, Surge	A/C Pipe Inc.
	AMES Co. Inc.
	APCO/Valve & Primer Corp.
	Cla-Val Co. Div. of Griswold Industries
	FEBCO Sales
	GA Industries Inc.
	Keystone Valve-USA
	Muesco Inc.
	Ocean Valve Inc.

TABLE C-5 (Continued)

Product	Supplier Name
Valves, Tapping	A/C Pipe Inc. American Cast Iron Pipe Co. Clow Corp. Concord-Daigle Inc. EBAA Iron Inc. Mueller Co. Patterson Pump Co. Joseph G. Pollard Co. Inc. US Pipe & Foundry Co. Waterous Co.
Water Level Indicators	Fischer & Porter Co. Environmental Div. Fisher Research Lab. Johnson Screens Inc. McCrometer, Div. of Ametek Inc. Joseph G. Pollard Co. Inc.
Well Casings	American Cast Iron Pipe Co. Certain-Teed Corp. Pipe & Plastics Group L. B. Foster Co. Koch Fiberglass Products
Well Screens	Certain-Teed Corp. Pipe & Plastics Group L. B. Foster Co. Johnson Screens Inc. Koch Fiberglass Products Layne & Bowler Inc.

Source: American Water Works Association 1986 Buyers' Guide.

TABLE C-6

SUPPLIER DIRECTORY

A/C Pipe Inc.*
Boro & Secane Rd.
Box 443
Primos, PA 19018

A/C Pipe Producers Assn.
1600 Wilson Blvd.
Suite 1008
Arlington, VA 22209

Advanced Polymer Systems Inc.
3696C Haven Ave.
Redwood City, CA 94063

Allied Chemical Co.
Box 1139R
Morristown, NJ 07960

Amalga Corp.
10600 W. Mitchell St.
West Allis, WI 53214

American Cast Iron Pipe Co.
Box 2727
Birmingham, AL 35202

American Concrete Pressure Pipe Assn.
8320 Old Courthouse Rd.
Vienna, VA 22180

Ameron
4700 Ramona Blvd.
Box 3000
Monterey Park, CA 91754

Ameron Fiberglass Pipe Div.
7676 Hillmont, Suite 190
Houston, TX 77040

Ames Co. Inc.
1485 Tanforan Ave.
Box 1387
Woodland, CA 95695

Ametek/Plymouth Products Div.
502 Indiana Ave.
Sheboygan, WI 53081

Amocams Inc.
419 S. Eisenhower Lane
Lombard, IL 60148

Apac Products
5828 Naylor Ave.
Livermore, CA 94550

Apco/Valve & Primer Corp.
1420 S. Wright Blvd.
Schaumburg, IL 60193

Auma Actuators Inc.
4 Zesta Dr.
Pittsburgh, PA 15205

Aurora Pump, Unit of General Signal Corp.
800 Airport Rd.
North Aurora, IL 60542

Autocon Industries Inc.
995 University Ave.
St. Paul, MN 55104

Badger Meter Inc.
4545 W. Brown Deer Rd.
Box 23099
Milwaukee, WI 53223

TABLE C-6 (Continued)

Bermad Irrigation Controls
Kibbutz Evron
Post Ashrat, Israel,
04-949-241

Berntsen Inc.
Box 8666
Madison, WI 53708

Bibby-Ste. Croix Foundries Inc.
6200 Principale BP280
Cte, Lotbiniere
Ste. Croix, PQ, GOS 2HO, Canada

BIF, Unit of General Signal Corp.
1600 Division Rd.
West Warwick, RI 02893

Bingham & Taylor Corp.
Nalle St.
Culpeper, VA 22701

F. S. Brainard & Co.
231 Penn St.
Burlington, NJ 08016

Bristol Babcock Inc.
40 Bristol St.
Waterbury, CT 06708

Brooks Products Inc.
10141 Olney St.
El Monte, CA 91731

Brown & Caldwell Laboratories
1255 Powell St.
Emeryville, CA

Buckhorn Rubber Products
Box 998
Hannibal, MO 63401

Burke Industries
2250 S. Tenth St.
San Jose, CA 95112

Byron Jackson Pump Div., Borg-Warner
Box 22634
Long Beach, CA 90801

Capco Pipe Co. Inc.
1400 S. 20th St.
Box 3435
Birmingham, AL 35255

Capital Controls Co. Inc.
Box 211
Colmar, PA 18915

Carlisle Syntec Systems,
Div. Carlisle Corp.
Box 7000
Carlisle, PA 17013

Carlon Meter Co.
715 Robbins Rd.
Grand Haven, MI 49417

Carus Chemical Co.
1500 Eighth St.
La Salle, IL 61301

Certain-Teed Corp. Pipe &
Plastic Group
Box 860
Valley Forge, PA 19482

Chemply, Div. of United
Chemicals Inc.*
Box 18049
Pittsburgh, PA 15236

Christy Concrete Products Inc.
44100 Christy St.
Fremont, CA 94538

Cla-Val Co., Div. of
Griswold Industries
Box 1325
Newport Beach, CA 92663

Clow Corp.
300 S. Gary Ave.
Carol Stream, IL 60187

Columbus Standard Water
Works Equipment Co.
Box 8227
Columbus, GA 31908

TABLE C-6 (Continued)

Concord-Daigle Inc.
77 Maplecrete Rd.
Concord, ONT, L4K 1A5, Canada

Confab Industrial S.A.
Alameda Rio Negro
Barueri, Sao Paulo, 06400, Brazil

Crispin Valve Div., Multiplex Mfg. Co.
600 Fowler Ave.
Berwick, PA 18603

Culligan USA
One Culligan Pkwy.
Northbrook, IL 60062

Cypro Inc.
1361 N. First St.
Box 225
Hampstead, MD 21074

Dallas Specialty & Mfg. Co.
11221 Stemmons Fwy.
Dallas, TX 75229

Dezurik
Sartell, MN 56377

Dorr-Oliver Inc.
77 Havemeyer Lane
Box 9312
Stamford, CT 06904

Dresser Mfg. Div., Dresser Industries
41 Fisher Ave.
Bradford, PA 16701

Dyna-Torque Inc.
1934 E. Sherman Blvd.
Muskegon, MI 49444

EBAA Iron Inc.
Box 857
Eastland, TX 76448

East Jordan Iron Works Inc.
Box 439
East Jordan, MI 49727

Emery Industries Div. NDCC
4900 Este Ave.
Cincinnati, OH 45232

FEBCO Sales
1550 N. Peach
Box 8070
Fresno, CA 93747

Fischer & Porter Co. Environmental Div.
County Line Rd.
Warminster, PA 18974

Fisher Research Lab
1005 I St.
Los Banos, CA 93635

Fisher Tank Co.
3131 W. Fourth St.
Chester, PA 19013

Flomatic Corp.
Box 100
North Hoosick, NY 12133

Fluid Conservation System Corp.
2120 W. Braker Lane
Suite E
Austin, TX 78758

Ford Meter Box Co. Inc.
775 Manchester Ave.
Box 443
Wabash, IN 46992

Jay Forni Inc.
2449 Bates Ave.
Concord, CA 94520

L. B. Foster Co.
415 Holiday Dr.
Pittsburgh, PA 15220

Foxboro Municipal Sales Div., The Foxboro Co.
Foxboro, MA 02035

Table C-6 (Continued)

GA Industries Inc.
290-D Marshall Rd.
Mars, PA 16046

Grifford-Hill-American Inc.
Box 47470
Dallas, TX 75247

Girard Industries, Inc.
6531 Addicks-Fairbanks Rd.
Houston, TX 77041

Goodall Rubber Co.
Box 8237
Trenton, NJ 08650

Griffin Pipe Products Co.
2000 Spring Rd.
Oak Brook, IL 60521

Hach Co.
Box 389
Loveland, CO 80539

Hankin Environmental Systems Inc.
71 Rte. 206 S.
Somerville, NJ 08876

Harco Corp.
1055 W. Smith Rd.
Medina, OH 44256

Harrington Corp.
Box 10335
Lynchburg, VA 24506

Hayward Tyler Inc.
1611 S. Pacific Coast Hwy.
Suite 206
Redondo Beach, CA 90277

Heath Consultants Inc.
100 Tosca Dr.
Box CS-200
Stoughton, MA 02072

Hersey Products Inc.
250 Elm St.
Dedham, MA 02026

Hungerford & Terry Inc.
226 Atlantic Ave.
Box 45
Clayton, NJ 08312

Husky Industries Inc.
Industrial Div.
Rte. 5, Box 275
Dunnellon, FL 32630

Hydra-Shield Mfg. Inc.
2701 W. Airport Fwy.
Suite 110
Irving, TX 75062

ITT Grinnell Corp.
Box 12957
Oakland, CA 94604

Industrial Filter & Pump Mfg.
5900 W. Ogden Ave.
Cicero, IL 60650

Infilco Degremont Inc.
Box 29599
Richmond, VA 23229

Integrated Efficiency Systems
Box 484
La Puente, CA 91747

JCM Industries Inc.
Box 580
Nash, TX 75569

J-M Mfg. Co. Inc.
1051 Sperry Rd.
Stockton, CA 95206

Jenkins Canada Inc.
170 St. Joseph Blvd.
Lachine, PQ H8S 2L6, Canada

Johnson Screens Inc.
Box 64118
St. Paul, MN 55164

James Jones Co.
4127 Temple City Blvd.
El Monte, CA 91734

TABLE C-6 (Continued)

Kendall Co.
One Federal St.
Boston, MA 02101

Kennedy Valve, Div. of ITT
Grinnell Valve Co. Inc.
1021 E. Water St.
Elmira, NY 14901

Kent Meters Inc.
Box 1852
Ocala, FL 32678

Keystone Valve-USA
9700 W. Gulfbank
Houston, TX 77040

Klett Mfg. Co. Inc.
179 E. 87th St.
New York, NY 10028

Koch Fiberglass Products
Box 8168
Wichita, KS 67208

Krofta Engrg. Corp.
101 Yokun Ave.
Lenox, MA 01240

P. E. LaMoreaux & Asso.
2612 University Blvd.
Tuscaloosa, AL

Layne & Bowler Inc.
Box 8097
Memphis, TN 38108

F. B. Leopold Co.
227 S. Division St.
Zelienople, PA 16063

Liquid Metronics Inc.
19 Craig Rd.
Acton, MA 01720

Long Beach Iron Works Inc.
2100 W. Anaheim St.
Long Beach, CA 90813

Magotteaux Canada SCC
601 Champlain St.
Magog, PQ J1X 3W9, Canada

McCrometer Div. of Ametek Inc.
3255 W. Stetson Ave.
Hemet, CA 92343

A. Y. McDonald Mfg. Co.
Box 508
Dubuque, IA 52001

McNally Pittsburg Inc. Valve
Box 1538
Pittsburg, KS 66762

Metrotech Corp.
670 National Ave.
Mountain View, CA 94043

Miles Ets
Box 40
Elkhart, IN 46515

Montgomery Laboratories
250 N. Madison
Pasadena, CA 11109

Mueller Co.
500 W. Eldorado St.
Box 671
Decatur, IL 62525

Muesco Inc.
Box 14239
Houston, TX 77221

Na Con Services Inc.
800 Jorie Blvd.
Oak Brook, IL 60521

Nalco Chemical Co.
2901 Butterfield Rd.
Oak Brook, IL 60521

Nappco Inc.
77 Main St.
Northborough, MA 01532

TABLE C-6 (Continued)

National Sanitation Foundation
P.O. Box 1468
Ann Arbor, MI 48106

Ocean Valves Inc.
1304 Langham Creek Dr.
Suite 450
Houston, TX 77084

Olin Corp. Chemicals Group
120 Long Ridge Rd.
Stamford, CT 06904

Orlando Laboratories Inc.
P.O. Box 19127
Orlando, FL 32814

PGL Corp.
1201 N. McDowell Blvd.
Petaluma, CA 94952

Paterson Candy Intl. Ltd.
21 The Mall
Ealing, London W5 2PU
United Kingdom

Patterson Pump Co.
Box 790
Toccoa, GA 30577

Peabody Tec Tank
South Industrial Park
Box 996
Parsons, KS 67357

Perkin-Elmer Co.
Main Ave.
Norwalk, CT 06859

Pilot Mfg. Co.
20433 Earl St., Box 3128
Torrance, CA 90510

Pittsburgh-Des Moines Corp.
Neville Island
Pittsburgh, PA 15225

Joseph G. Pollard Co. Inc.
New Hyde Park, NY 11040

Polly Pig by Knapp Inc.
1209 Hardy St.
Houston, TX 77020

Pont-A Mousson S.A.
91 Ave. de la Liberation 4x
54017 Nancy-Cedex, France

Pow-R Devices Inc.
5940 Goodrich Rd.
Clarence Center, NY 14032

Henry Pratt Co.
401 S. Highland Ave.
Aurora, IL 60507

Price Brothers Co.
367 W. Second St., Box 825
Dayton, OH 45401

Princeton Testing Laboratories
P.O. Box 3108, U.S. Rte. 1
Princeton, NJ 08543

Progressive Fabricators Inc.
6880 N. Broadway Ave.
St. Louis, MO 63147

QEI Inc./Quindar
60 Fadem Rd.
Springfield, NJ 07081

Quazite Corp.
5515 Gasmer
Houston, TX 77035

Radiodetection Corp.
615 Franklin Turnpike
Ridgewood, NJ 07451

Reed Mfg. Co.
1425 W. Eighth St.
Box 1321
Erie, PA 16512

Reeves Rubber Div.,
Fluorocardon Co.
415 Pico
San Clemente, CA 92672

TABLE C-6 (Continued)

Reilly Tar & Chemical Corp.
1510 Market Square Center
151 N. Delaware St.
Indianapolis, IN 46204

Rio Linda Chemical Co. Inc.
410 N. Tenth St.
Sacramento, CA 95814

Roberts Filter Mfg. Co.
Sixth & Columbia Ave.
Box 167
Darby, PA 19023

Rockwell Intl. Municipal & Utility Div.
400 Lexington Ave.
Pittsburgh, PA 15208

Romac Industries Inc.
Box 3212
Seattle, WA 98114

Russell Pipe & Foundry Co. Inc.
Box 519
Alexander City, AL 35010

Scepter Mfg. Co. Ltd.
807 Pharmacy Ave.
Scarborough, ONT M1L 3K2, Canada

Schonstedt Instrument Co.
1775 Wiehle Ave.
Reston, VA 22090

Seiscor Technologies Inc./ Vericom Telemetry Systems
Box 470580
Tulsa, OK 74147

Signet Scientific Co.
3401 Aerojet Ave.
El Monte, CA 91734

A. O. Smith Harvestore Products, Inc.
1300 Grove Ave.
Barrington, IL 60010

Smith Industries Inc.
8300 Hempstead Hwy.
Box 7398
Houston, TX 77248

Southern Products & Silica Co.
DWR. 189
Hoffman, NC 28347

Stanley Hydraulic Tools
3810 S.E. Naef Rd.
Milwaukee, OR 97222

Sterling Div., Reichhold Chemicals
Ohio River Blvd.
Haysville Borough
Sewickley, PA 15143

Stiles-Kem, Div. of Met-Pro Corp.
3301 Sheridan Rd.
Zion, IL 60099

Stockham Valves & Fittings
Box 10326
Birmingham, AL 35202

Taisei Kiko Co. Ltd.
Osaka Ekimae Daisan Bldg.
1 Umeda 1 Chome Kita Ku
Osaka 530, Japan

Technical Products Corp.
Box 7607
Portsmouth, VA 23707

Temcor
Box 3039
Torrance, CA 90510

Texas Foundries Inc.
1611 N. Raguet St.
Box 3718
Lufkin, TX 75903

Tonka Equipment Co.
5115 Industrial St.
Maple Plain, MN 55359

TABLE C-6 (Continued)

Trico Industries Inc.
5400 Kansas Ave.
Kansas City, KS 66110

Trinity Valley Iron & Steel Co.*
Box 2388
Fort Worth, TX 76113

Troy Valve
650 Railroad St., Box 187
Troy, PA 16947

Turbitrol Co.
415 E. Paces Ferry Rd., Box 12047
Atlanta, GA 30328

Tyler Pipe
Box 2027
Tyler, TX 75710

Unifilt Corp.
Box 97
Zelienople, PA 16063

U.S. Pipe & Foundry Co.
Box 10406
Birmingham, AL 35202

Val-Matic Valves & Mfg. Corp.
905 Riverside Dr.
Elmhurst, IL 60126

Vianini Pipe Inc.
81 County Line Rd., Box D
Somerville, NJ 08876

E. H. Wachs Co.
100 Shepard St.
Wheeling, IL 60090

Walker Process Corp.
840 N. Russell Ave.
Aurora, IL 60507

Wallace & Tiernan, Div.
Pennwalt Corp.
25 Main St.
Belleville, NJ 07109

Waterman Industries Inc.
Box 458
Exeter, CA 93221

Waterous Co.
300 John E. Carroll Ave. E.
South St. Paul, MN 55075

Watertower Paint & Repair Co.
Box 67
Clear Lake, IA 50428

Watts Regulator Co.
Box 628
Lawrence, MA 01842

Western Chemical Co.
1345 Taney
North Kansas City, MO 64116

Western Land Roller Co.
1341 W. Second St., Box 668
Hastings, NE 68901

Roy F. Weston Inc.
256 Welsh Pool Rd.
Lionville, PA 19353

Worthington Pump Div.,
Dresser Industries Inc.
270 Sheffield St.
Mountainside, NJ 07092

Zurn Industries Inc., Hays
Fluid Controls Div.
Box 300
Gastonia, NC 28052

Source: American Water Works Association 1986 Buyers' Guide.
*Distributor only.

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